DOCUMENT RESUME

ED 151 182 SE 023 938

AUTHOR Bever, Wayne; And Others
TITLE Illinois Pesticide Applicator Study Guide. A Training Manual for Private and Commercial Pesticide Applicators and Operators. Special Publication 39.
INSTITUTION Illinois Univ., Urbana. Coll. of Agriculture.; Illinois Univ., Urbana. Cooperative Extension Service.
PUB DATE [77]
NOTE 86p.; For related document, see SE 023 952; Contains occasional light type; Photographs may not reproduce well

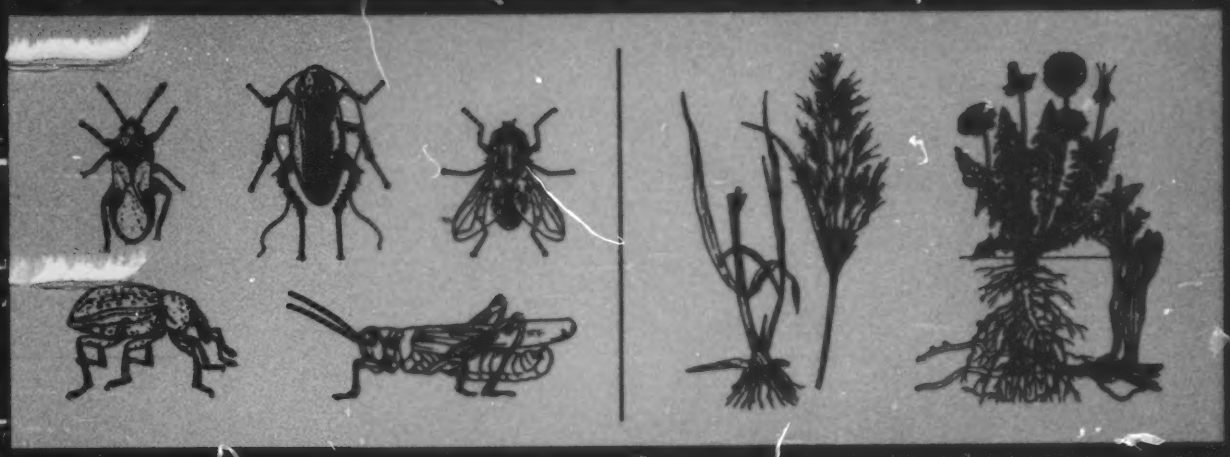
EDRS PRICE MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS *Certification; Entomology; *Environmental Education; Equipment Standards; Federal Legislation; *Pesticides; *Pollution; *Public Health; Safety
IDENTIFIERS *Illinois; Labels

ABSTRACT

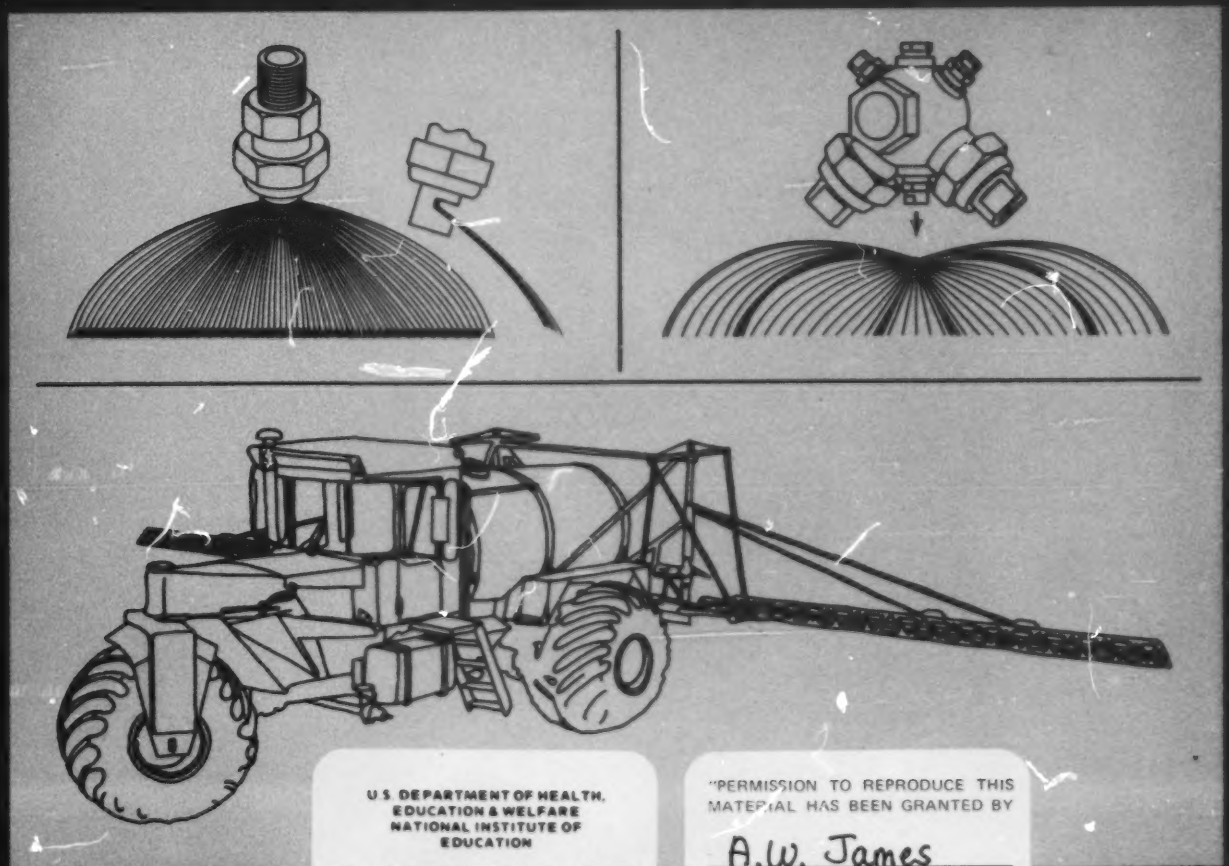
This study guide is designed to provide the necessary information to prepare for certification as a private or commercial pesticide applicator. In addition to providing basic information covering the various sections of the amended Federal Insecticide, Fungicide, and Rodenticide Act, it contains a glossary of common pesticide terms, a list of poison control centers and directions for obtaining certification. Chapter topics include: understanding pesticides, human poisoning, safe handling labels, application and calibration, insects, plant diseases and weeds, and laws and regulations. (CS)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

ED151182



# ILLINOIS PESTICIDE APPLICATOR STUDY GUIDE



U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

A.W. James

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

SE 023 738

A TRAINING MANUAL
FOR PRIVATE AND COMMERCIAL
PESTICIDE APPLICATORS AND OPERATORS

# ILLINOIS PESTICIDE APPLICATOR STUDY GUIDE


PREPARED BY

WAYNE BEVER, DEPARTMENT OF PLANT PATHOLOGY
LOREN BODE, DEPARTMENT OF AGRICULTURAL ENGINEERING
BARRY J. JACOBSEN, DEPARTMENT OF PLANT PATHOLOGY
MARSHAL D. McGLAMERY, DEPARTMENT OF AGRONOMY
STEVENSON MOORE III, OFFICE OF AGRICULTURAL ENTOMOLOGY

AND THE AGRICULTURAL PESTICIDE COMMITTEE



COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
COLLEGE OF AGRICULTURE

IN COOPERATION WITH THE
ILLINOIS NATURAL HISTORY SURVEY

SPECIAL PUBLICATION 39

# PREFACE

Pesticides play an important role in controlling pests. They protect humans, animals, and plants from diseases, parasites, and predators; prevent damage to houses and other buildings; and improve the production of food, feed, and fiber. But pesticides should be used only when necessary, and they must be applied wisely, stored safely, and disposed of properly.

Over a 15-year period (1961-1975), 35 people died in Illinois from pesticide poisoning. Pesticides also accounted for 6 percent (about 650 cases annually) of the accidental ingestion of hazardous substances by Illinois children under 12 years of age. Although this percentage is considerably lower than that for medicine (57.5 percent) or household preparations (13.1 percent), the important point is that accidents do occur as a result of using pesticides. All pesticides should be treated as potential poisons that may endanger some part of our natural environment — people, pets, wildlife, plants, or water.

In 1972, Congress amended the 1947 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to extend federal regulations to all pesticides instead of only those shipped across state lines. FIFRA now provides stronger enforcement in the use and application of pesticides, and requires that all persons planning to use or supervise the use of restricted use pesticides be certified as competent.

New state laws and regulations designed to meet the federal standards set forth in the amended FIFRA require that a Commercial Pesticide Applicator or Operator pass a written examination before obtaining a license, and that a Private Pesticide Operator attend a training session conducted by the Cooperative Extension Service, University of Illinois at Urbana-Champaign before he can be certified to purchase or use restricted use pesticides.

This *Illinois Pesticide Applicator Study Guide* will help prepare you for certification as a Private Pesticide Operator or as a Commercial Pesticide Applicator or Operator. In addition to providing basic information covering the various sections of the amended Federal Insecticide, Fungicide, and Rodenticide Act, it contains a glossary of common pesticide terms, a list of poison control centers in Illinois (Appendix I), and directions for obtaining certification (Appendix II).

The authors wish to express their appreciation to various federal and state agencies for free use of source materials, and to Gary Larson, U.S. Department of the Interior, Fish and Wildlife Service, Springfield, Illinois, for the section on rodents and birds in Chapter 7.

# CONTENTS


CHAPTER ONE: UNDERSTANDING PESTICIDES . . . . . 1
- Types of Pesticides . . . . . 1
- Chemical Nature of Pesticides . . . . . 2
- Pesticide Formulations . . . . . 2
- Pesticide Compatibility . . . . . 4
- Synergism . . . . . 4
- Adjuvants . . . . . 4
- Pesticide Residues and Tolerances . . . . . 4
- Toxicity and Hazards of Pesticides . . . . . 4

CHAPTER TWO: HUMAN PESTICIDE POISONING . . . . . 9
- Exposure to Pesticides . . . . . 9
- Symptoms of Pesticide Poisoning . . . . . 10
- Treatment of Pesticide Poisoning . . . . . 12

CHAPTER THREE: SAFE HANDLING OF PESTICIDES . . . . . 14
- Protective Clothing and Equipment . . . . . 14
- Respirators . . . . . 15
- Mixing and Loading Pesticides . . . . . 16
- Applying Pesticides . . . . . 16
- Pesticide Cleanup . . . . . 17
- Storing Pesticides . . . . . 18
- Disposing of Pesticides and Containers . . . . . 20

CHAPTER FOUR: LABELS AND LABELING . . . . . 22
- Information on the Label . . . . . 22
- Reading the Label . . . . . 23

CHAPTER FIVE: APPLICATION EQUIPMENT AND CALIBRATION . . . . . 26
- Ground Sprayers . . . . . 26
- Dusters and Granular Applicators . . . . . 34
- Fumigators and Injectors . . . . . 35
- Aerosol Generators and Foggers . . . . . 36
- Aerial Sprayers . . . . . 36
- Aerial Dusters and Granular Applicators . . . . . 38

CHAPTER SIX: PESTICIDES IN THE ENVIRONMENT . . . . . 39
- Movement of Pesticides . . . . . 39
- Persistence of Pesticides . . . . . 40

CHAPTER SEVEN: INSECTS, INSECT RELATIVES, RODENTS, AND BIRDS . . . . . 45
- Insects and Insect Relatives . . . . . 45
- Rodents and Birds . . . . . 50

CHAPTER EIGHT: PLANT DISEASES AND WEEDS . . . . . 52
- Plant Diseases . . . . . 52
- Weeds . . . . . 60

CHAPTER NINE: PESTICIDE LAWS AND REGULATIONS . . . . . 63
- Federal Environmental Pesticide Control Act . . . . . 63
- Illinois Laws and Regulations . . . . . 63
- Federal and Illinois Laws Protecting Birds . . . . . 66

CHAPTER TEN: GLOSSARY OF COMMON PESTICIDE TERMS . . . . . 69

APPENDIX I: POISON TREATMENT CENTERS IN ILLINOIS . . . . . 73

APPENDIX II: INSTRUCTIONS FOR OBTAINING CERTIFICATION . . . . . 77

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. JOHN B. CLAAR, *Director*, Cooperative Extension Service, University of Illinois at Urbana-Champaign. The Illinois Cooperative Extension Service provides equal opportunities in programs and employment. (November, 1975)

Revised printing

20M—8-77—37680—RGM

# CHAPTER ONE: UNDERSTANDING PESTICIDES

## TYPES OF PESTICIDES

A pesticide is any chemical used to destroy, prevent, or control pests. Often the word "insecticide" is mistakenly used interchangeably with the word "pesticide." An insecticide, however, is simply one type of pesticide. Fungicides, herbicides, and rodenticides are also kinds of pesticides.

### Insecticides

Insecticides are chemicals used to control insects and other related animals such as ticks, spiders, centipedes, and mites. Certain insecticides kill the insect on contact; others have to be inhaled or swallowed by the insect to be effective. Some insecticides kill both by touch and by swallowing. Insecticides called **systemics** may be absorbed, injected, or fed into the plant or animal to be protected. Then, when the insect feeds on the plant or animal, it consumes the systemic chemical and dies.

Some insecticides kill only a few kinds of insects. Many more insecticides, however, are general purpose or wide-range killers. These **broad-spectrum insecticides** are used when several different kinds of insects are a problem. No broad-spectrum insecticide kills all insects; each varies in the kinds and number of insects it controls.

Insecticides also vary in the length of time that they are effective as killing agents. Some break down almost immediately into nontoxic byproducts. For example, **nonresidual insecticides** are often used in homes and dwellings where people and domestic animals might be exposed. Other insecticides remain active for a fairly long time. **Residual insecticides** are particularly useful when the insects are a constant control problem, and when the chemicals will not be an environmental hazard. For example, residuals are often used for fly control in livestock buildings or for termite control in and around wooden structures.

### Fungicides

Fungicides are chemicals used to prevent or control fungi that cause rots, leaf spots, blights, mildews, rusts, and other plant diseases.

Fungicides vary in the number of fungi they inhibit or kill. **Narrow-spectrum fungicides** are effective against only a few fungi. **Broad-spectrum fungicides** are effective against a large number of fungi, but no one fungicide is effective against all fungi. Before choosing a fungicide, be sure that you know which fungal plant disease you are attempting to control, and whether the fungicide is registered for this purpose.

Most fungicides must be applied to the surface of the plant before the fungus enters. Once the disease organism has penetrated the plant tissues, it is no longer controllable with **surface protectants.**

A recently developed group of chemicals are classed as **systemic fungicides.** These chemicals are absorbed by the plant and move through living tissues without harming the plant. Because of this capability, systemic fungicides can be used either as protectants, or to kill or inhibit the fungus after it has become established within plant tissue.

Since fungi infect microscopic areas of the plant, thorough coverage of the plant surface is extremely important. Overdosing, however, can injure the plant.

### Herbicides

Herbicides are classified as **selective** or **nonselective,** depending upon how they are used for weed control.

Selective herbicides kill certain plants with little or no injury to agronomic, vegetable, range, turf, or horticultural crops. Usually, selective herbicides will kill either most broad-leaved plants or most grassy plants, and are useful for row crops, pastures, lawns, and golf courses, or in other areas with desirable trees or plants. Certain highly selective herbicides, such as lawn crabgrass killers, may kill only certain plants within a group.

Nonselective herbicides are used where selectivity is not intended or desirable, as in noncrop weed control. These herbicides are toxic to all plants, and can be used in industrial areas or for trimming fencerows, driveways, walks, etc. Plants differ in their susceptibility to any specific chemical, and the choice of herbicide and application rate depends upon the weed species to be controlled. Both selective and nonselective herbicides are

available that can be applied to the foliage of growing plants or to the soil surface.

The timing of herbicide applications is important. The directions on the label state when to apply the herbicide for best results. **Preplanting** treatments are made before the crop is planted, and **preemergence** treatments are made after the crop is planted but before the crop or weeds appear. **Postemergence** treatments, which are made after the crop or weeds appear, control the weeds but leave the crop unharmed. Often the chemical will be applied postemergence to the crop but preemergence to the weeds.

### Rodenticides

Rodenticides are chemicals used to control rats, mice, and other rodents. Because of the hazard to domestic animals or desirable wildlife, rodenticides are usually applied as baits in limited areas such as runways or known feeding places. Chemicals that control other mammals, birds (avicides), and fish (piscicides) are also grouped in this category by regulatory agencies.

### Growth Regulators and Harvest Aids

A plant or growth regulator changes the normal growth or reproduction of a plant. Some growth regulators are used to move up or move back the normal harvest date for the crop. Growth regulators include hormones and synthetic and naturally occurring substances, and should be treated like other pesticides as far as environmental conditions, species, concentration, and time of application are concerned.

Materials generally referred to as "harvest-aid" chemicals fall into two classes: **defoliants** that induce the plant to drop (abscise) its leaves but do not kill the plant, and **desiccants** that draw the moisture from a plant, causing it to wither and die.

### Nematicides

Nematicides are chemicals used to control nematodes. Nematodes are tiny, almost transparent, hairlike worms that often live in the soil and feed on plant roots. Fumigants are generally used to control nematodes in the soil. Soil fumigants are divided into two classes: those that can be used only as preplant treatments because of phytoxicity, and those that can be safely applied to established living plants.

### Other Pesticides

In addition to the pesticides discussed in the preceding sections, many other types of pesticides are used to control specific pests. These include **miticides** for the control of mites; **molluscicides** for the control of snails and slugs; **repellents** to divert a pest from a crop, animal, or structure; **attractants** to lure a pest to a particular location; and **bactericides** for the control of bacteria.

## CHEMICAL NATURE OF PESTICIDES

Pesticides can be classified into the following three groups according to their origin:

(1) Inorganic pesticides of mineral origin. The more common elements used to make inorganic pesticides are arsenic, copper, boron, sulfur, tin, and zinc.

(2) Plant-derived organic pesticides extracted from plants or plant parts. Some common plant-derived organic pesticides are rotenone, red squill, pyrethrins, and strychnine.

(3) Synthetic or man-made organic pesticides containing carbon, hydrogen, and several other elements such as chlorine, phosphorus, and nitrogen. Examples of synthetic organic pesticides are 2,4-D, atrazine, captan, parathion, and carbaryl.

## PESTICIDE FORMULATIONS

A pesticide can rarely be used as originally manufactured. It must be diluted with water, oil, air, or chemically inert materials so that it can be applied evenly over the area to be treated.

Usually, the active ingredient cannot be used directly, and the manufacturer must further modify his product by combining it with other materials, such as solvents, wetting agents, stickers, powders, or granules. The final product is called a **pesticide formulation,** and is ready for use, either as packaged or diluted with water or some other carrier.

A single pesticide is often sold in several different formulations. In deciding which formulation to purchase, you should consider its effectiveness against the pest; the habits of the pest; the plant, animal, or surface to be protected; the application equipment; the danger of drift and runoff, and possible damage to the protected surface.

Abbreviations are sometimes used to describe the type of formulation involved. In the following listing, the abbreviation is given in parentheses.

### Solutions (S)

The pesticide is formulated in an appropriate solvent or water and forms a true solution. Solutions, if properly prepared for special uses, do not leave unsightly residues, and will not clog spray equipment.

### Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate is a liquid formulation of a pesticide that can be mixed with water to form an emulsion. An emulsion is one liquid dispersed (usually as small globules) throughout another liquid.

Many pesticide active ingredients are not soluble in water but are soluble in oils. In emulsifiable concentrates, the active ingredient is often dissolved in an oil, and an emulsifying agent is added so that the EC can be conveniently mixed with water to form a "milky" emulsion. Emulsifiable concentrates are nonabrasive and relatively harmless to equipment. Little agitation in the spray tank is usually required when using EC's. When EC's are combined with other products, special mixing, agitation, or compatibility agents may be needed to prevent separation.

### Wettable Powders (WP)

Wettable powders are dry, powdered pesticide formulations that resemble dusts. Unlike dusts, however, they contain wetting and dispersing agents. They are made to mix with water; and when mixed, they form a suspension. Strong agitation is needed in the spray tank to keep the formulation in suspension, since it does not form a true solution.

Properly prepared wettable powder formulations spray well and do not clog nozzles, but they may be abrasive to pumps and nozzles. Most wettable powder formulations are less likely to damage plants than EC formulations.

### Soluble Powders (SP)

Soluble powders, like wettable powders, are dry formulations. When soluble powders are added to water, however, they dissolve and form true solutions. Agitation in the spray tank is sometimes required to get soluble powders into solution. Once the powders are in solution, no further agitation is necessary.

### Flowables (F)

A flowable is a finely ground wettable powder formulation. It is sold as a thick suspension in a liquid to facilitate its addition to water in the spray tank. Flowables require only moderate agitation and seldom clog spray nozzles. An increasing number of chemical formulations are called **liquids** (L). In general, liquids are the same as flowables.

### Dusts (D)

A dust formulation usually consists of the active ingredient mixed with an inert material, such as a talc, clay, powdered nut hulls, volcanic ash, or similar materials. All of the ingredients are finely ground to a fairly uniform particle size. Other inert materials are often added so that the formulation will store well and handle properly.

Dusts are always used dry, and should never be mixed with water. The very small particles in dusts make them subject to drift into nontarget areas during application. Dust formulations are used primarily to coat seed, plants, or animals in controlling insects, diseases, or other pests.

### Granules (G)

Granular formulations are made by applying a liquid formulation of the active ingredient to particles of clay or other porous materials such as corncobs or walnut shells. The granule carrier is prepared in advance to a standard size, and then the liquid formulation is added. The liquid active ingredient is absorbed into the granule or coats the outside of the granule.

Granular pesticides are used most often as soil treatments, and may be applied directly to the soil or over plants. A pesticide formulated on granules is usually safer to apply than liquid or dust formulations.

### Fumigants

Fumigants are pesticides or mixtures of pesticides that produce vapors. Fumigants are used to control rodents, insects, mites, nematodes, weeds, and plant disease-causing organisms. Most fumigants are liquids when purchased; when released, however, they change into a gas. Fumigants are commonly injected into the soil, released under tarpaulins, ore used in buildings to control pests.

### Aerosols

An aerosol formulation is in a can under pressure. The propellant expels the formulation through a fine spray opening. Convenience is the major advantage of using aerosols. They are used principally in the garden and home and occasionally in greenhouses and barns. They are seldom used in commercial agriculture. In addition to pressurized aerosols, thermal and mechanical aerosols are used in special situations.

### Poisonous Baits

A poisonous bait formulation is a pesticide mixed with water, food, or other attractive substance. The bait should be placed so that it is convenient to the target animals. Because of the attraction of the bait base, the animals will eat enough pesticide to kill them. Bait formulations are useful in controlling mice, rats, and other rodents. Either large or small areas can be treated with bait formulations.

## PESTICIDE COMPATIBILITY

When two or more pesticides can be safely mixed together or used at the same time, they are said to be **compatible.** Some pesticides are incompatible because they will not mix chemically. Incompatible pesticides may, when mixed, combine chemically and form another compound.

Before you mix pesticides or a pesticide and another material such as fertilizer, you should know if you will get the maximum benefit from both. One reason for combining pesticides is to save time. If the combined pesticides are not compatible, however, you may get poor or no control, or even injure the crop.

The pesticide label may indicate incompatibility between two or more materials. Some pesticide formulations are prepared for mixing with other materials. The pesticide label will indicate whether the pesticide is registered for premixes or tank mixes. Make sure that the materials are compatible and cleared for the combination before mixing or using them together. Tank mixes are still a "gray area" for many pesticides. According to the U.S. Environmental Protection Agency (EPA), "If a mixture of fungicides and insecticides has been proven compatible from extensive usage, such usage may be continued."

## SYNERGISM

Synergism is the action of two materials of the same type that produce a greater cumulative effect when used together than when used individually. One material may not affect the pest when used alone, but may greatly increase the total effect of the two materials when they are used together. Synergism may increase control or decrease the amount of chemical required, but it may also harm nontarget organisms.

## ADJUVANTS

An adjuvant is a chemical added to a pesticide mixture that helps the active ingredient do a better job. Most pesticide formulations include a small percentage of adjuvants. Wetting agents and emulsifiers are needed so that the pesticide chemical will mix with water. Spreaders and stickers help make the active ingredient spread evenly over the treated surface and remain in place despite rain or wind. Penetrants aid the pesticide to penetrate the outer surface (leaf, root, and skin) and into other plant tissue.

The formulation, as manufactured, usually contains enough of these materials for many jobs, but sometimes extra additives are required. For example, when treating waxy surfaces such as cabbage or onion leaves, a spreader is necessary. These adjuvants are added directly to the spray tank. Be sure to use only the amount recommended, or you may end up with less deposit rather than more, resulting in poor control. Other types of additives include thickeners, invert emulsifiers, and foaming agents.

## PESTICIDE RESIDUES AND TOLERANCES

Modern analytical methods make it possible to detect very small amounts of pesticides in plant or animal products. Quantities as small as one part per million (ppm) and even one part per billion (ppb) can be detected on crops. One part per million is one pound in 500 tons, or one ounce in 63,000 pounds.

A **residue** is the amount of the pesticide or the chemical byproduct that can be found on or in a crop or animal to which the pesticide has been applied. Residues can result from pesticides applied to your crop, by drift from a neighbor's crop, from pesticide uptake by the plant from the soil, and even from storing a crop in an area previously treated with a pesticide.

Some pesticides, such as DDT, chlordane, and dieldrin, are highly persistent and last for a long period of time, even years. Some pesticides are not persistent and last only a few days. Naturally, the persistent pesticides are more likely to cause long-lasting residues.

The pesticide applicator must do everything possible to eliminate illegal residue problems. Many pesticides have warning statements on the label such as "Do not apply later than 14 days before harvest," or "Do not apply within 21 days of slaughter," or "Do not apply more than once." Follow these directions carefully.

A **tolerance** is the amount of pesticide residue established by law that may safely remain on or in food without injury to the consumer. The tolerance for a pesticide is set by the U.S. EPA.

A tolerance may be set for each pesticide and each pesticide use. For example, the tolerance for Pesticide X may be 2 ppm on carrots and 1 ppm for corn. If a tolerance is exceeded, the crop or animal product can be seized and the grower is liable for penalty.

It is essential that pesticide salesmen, dealers, growers, applicators, and others dealing in pesticides be familiar with pesticide residues and tolerances. All crops, including livestock, must reach the market free of excessive residues and within tolerance limits.

## TOXICITY AND HAZARDS OF PESTICIDES

Pesticides are poisonous. They have to be poisonous to kill undesirable plants, insects, diseases, or other pests. Safe and proper use of pesticides depends upon a knowledge of their toxic properties and a respect for the potential hazards associated with their use.

## Toxicity

Toxicity is the inherent capacity of a pesticide to produce injury or death. If you know the toxicity of a pesticide, you will know what precautions to take.

Tests are performed with each pesticide to determine the toxicity to rats, rabbits, guinea pigs, or other animals. These tests are helpful in determining how hazardous the pesticide probably would be to humans.

In oral tests, the animal is given quantities of the pesticide by mouth according to the animal's body weight. The dose is increased until the dose that will kill 50 percent of the test animals is found. This lethal dose (deadly amount) is called "Oral $LD_{50}$." The dose is expressed in milligrams per kilogram of body weight (mg/kg). There are 1,000 mg in a gram and 454 grams in a pound. A kilogram (kg) is 2.2 pounds. If a pesticide has an Oral $LD_{50}$ of 100, then 100 mg (1/10 of a gram) of the pesticide are required to kill 5 out of 10 test animals each weighing a kilogram. A compound with an Oral $LD_{50}$ of 100 is dangerous because 1/90 of a pound (1 to 2 teaspoons) could kill a human. The lower the $LD_{50}$ number, the more toxic the pesticide.

In dermal tests, the pesticide is placed on the skin of the test animal and covered with a bandage so that it will remain on the skin for 24 hours. If 100 mg of the pesticide are required to kill 5 out of 10 test animals weighing one kilogram, the Dermal $LD_{50}$ is 100.

In inhalation tests, the test animals are placed in an airtight container with specific quantities of the pesticide. The animals remain in the container for one hour. Inhalation values called $LC_{50}$'s are measured in micrograms per liter ($\mu$g/l). The $LC_{50}$ is the lethal concentration that will kill 50 percent of the test animals. There are 1,000 micrograms ($\mu$g) in one milligram (mg). One liter is equal to 1.06 quarts. An $LC_{50}$ of 100 means that 100 micrograms per one quart of air are required to kill 5 out of 10 test animals when they are exposed for one hour. $LC_{50}$ also refers to toxicities of fish in water, and is expressed in parts per million (ppm).

Table 1 gives the oral and dermal $LD_{50}$ and the inhalation $LC_{50}$ for pesticides with high, moderate, low, and very low toxicity. Highly toxic pesticides contain a drawing of a skull and crossbones and the words "Danger-Poison" on the label. Moderately toxic pesticides contain the word "Warning" on the label; and pesticides with low and very low toxicity contain the word "Caution" on the label. All pesticide labels carry a "Keep Out of Reach of Children" warning.

## Hazards

Do not depend upon toxicity values alone as a measure of the hazard of a pesticide to humans or other animals. You must also be concerned with the hazards associated with exposure to the pesticide.

Hazard and toxicity are not the same. Hazard is a combination of toxicity and exposure. It is the potential threat that injury will result from the use of a pesticide in a particular formulation or quantity. Some hazards do not involve toxicity to humans or other animals. For example, sulfur, oils, and numerous other chemicals are considered safe or relatively safe to animals but may cause considerable injury to some plants (phytotoxicity).

A compound may be extremely toxic but present little hazard when used (1) in a very dilute formulation; (2) in a formulation that is not readily inhaled or absorbed through the skin; (3) only occasionally and under conditions in which humans are protected with protective equipment and clothing; and (4) only by knowledgeable applicators who are properly equipped to handle the chemical safely.

Conversely, a chemical may be relatively nontoxic but present a hazard because it is normally used in a concentrated form that may be readily absorbed or inhaled. Or it may be used by the nonprofessional, such as the home gardener, who is not aware of the possible hazards to which he is being exposed.

A pesticide concentrate may be toxic if taken orally, but it may not be hazardous when diluted with water and applied by a knowledgeable applicator. Another pesticide may not be extremely toxic as it comes from the bottle, but it can be a hazard if it is used in a careless manner and allowed to get on the skin day after day.

Complete information is not available on the toxicity of all pesticides. For example, very little information is

*Table 1. Oral, Dermal, and Inhalation Toxicity Ratings of Pesticides*

| Toxicity rating | Label signal words | Oral $LD_{50}$ (mg/kg) | Dermal $LD_{50}$ (mg/kg) | Inhalation $LC_{50}$ ($\mu$g/l or ppm) | Lethal oral dose, 150-pound man |
|---|---|---|---|---|---|
| high | Danger-Poison | 0-50 | 0-200 | 0-2,000 | few drops to 1 teaspoon |
| moderate | Warning | 50-500 | 200-2,000 | 2,000-20,000 | 1 teaspoon to 1 ounce (2 tablespoons) |
| low | Caution | 500-5,000 | 2,000-20,000 | 20,000+ | 1 ounce to 1 pint+ or 2 pounds |
| very low | Caution | 5,000+ | 20,000+ | ... | 1 pint+ or 2 pounds+ |

available on the effects of commonly used fungicides (other than mercury) and herbicides on birds, fish, and bees. Insecticides have been more thoroughly studied.

Table 2 shows the uses and toxicity of some common fungicides, bacteriocides, and nematicides, including the acute oral $LD_{50}$ for rats and possible skin reactions of humans.

Table 3 shows the chemical class, uses, oral $LD_{50}$, worker reentry time, and toxicity of common insecticides. Birds, fish, and bees would not be exposed to insecticides used for soil, livestock, and household insect control.

Table 4 shows the chemical class, oral $LD_{50}$, and dermal toxicity and irritation of common herbicides. The common names listed in Table 4 are those approved by the Weed Science Society of America. Herbicides do not usually cause severe skin irritation, and most of them are not rapidly absorbed through the skin. However, you should always read the label, use rubber gloves, and take all necessary precautions.

*Table 2. Uses and Toxicity of Common Fungicides, Bactericides, and Nematicides*

| Common name | Trade name | Uses | Oral $LD_{50}$ (mg/kg) | Dermal irritation |
|---|---|---|---|---|
| anilazine | Dyrene | ornamentals, turf, vegetables | 2,710 | mild |
| benomyl | Benlate, Tersan 1991 | field crops, fruit, ornamentals, vegetables | 9,590 | none to mild |
| captafol | Difolatan | fruit, vegetables | 6,200 | mild to moderate |
| captan | Orthocide, Captan | field crops, fruit, vegetables | 9,000 | none to mild |
| carboxin | Vitavax | field crops | 3,200 | mild |
| chloroneb | Demosan, Tersan SP | field crops, turf | 11,000 | mild |
| chloropicrin | Larvacide, Picfume, Triclor | soil disinfestation | .8 | severe |
| chlorothalonil | Bravo, Daconil 2787, Exotherm Termil | fruit, turf, vegetables, ornamentals | 10,000 | mild |
| copper | many | fruit, ornamentals, vegetables | 3,000-6,000 | mild |
| cycloheximide | Acti-dione | ornamentals, turf | 2.0 | severe |
| DCNA | Botran | fruits, ornamentals, vegetables | 5,000 | mild |
| dazomet | Soil Fumigant M, Mylone | soil disinfestation | 500-650 | none |
| dibromochloropropane (DBCP) | Nemagon, Fumazone | nematicide | 172 | mild to severe |
| dichlone | Phygon | fruit, ornamentals, vegetables | 1,300 | mild |
| dichloropropenes | Telone, D-D, Nemafume | nematicide | 250 | mild |
| dinocap | Karathane | fruit, ornamentals, vegetables | 980 | mild |
| DNOC | Elgetol | fruit | 20 | severe |
| dodine | Cyprex | fruit, ornamentals | 1,000 | mild |
| ethazol | Koban, Terrazole, Truban | field crops, ornamentals, turf | 2,000 | mild |
| ethylene dibromide | many | nematicide | 146 | severe |
| fenaminosulf | Dexon | field crops, ornamentals, turf, vegetables | 60 | mild |
| ferbam | Karbam Black, Fermate | fruit, ornamentals | 17,000 | mild |
| folpet | Phaltan, Fungitrol | fruit, ornamentals, vegetables | 10,000 | mild |
| glyodin | Glyodin | fruit | 3,170 | none to mild |
| hexachlorobenzene | HCB, Anticarie, No Bunt | field crop seed treatment | 10,000 | not available |
| inorganic mercury | Calomel, Calo-Clor | turf | 100 | severe |
| lime-sulfur | many | fruit | NA | mild to moderate |
| maneb | Manzate D, Dithane M-22 | field crops, fruit, ornamentals, turf, vegetables | 6,750 | mild |
| mancozeb | Dithane M-45, Manzate 200 | field crops, fruit, ornamentals, turf, vegetables | 6,160 | mild |
| methyl bromide | many | soil disinfestation | 200 ppm (vapor) | severe |
| MIT | Vorlex Soil Fumigant, Trapex | soil disinfestation | 305 | severe |
| oxycarboxin | Plantvax | ornamentals | 3,200 | mild |
| parinol | Parnon | ornamentals | 5,000 | mild |
| PCNB | Terraclor | field crops, ornamentals | 1,650-12,000 | mild |
| piperalin | Pipron | ornamentals | 2,500 | mild |
| polyram | Polyram | fruit, ornamentals, vegetables | 6,400 | mild |
| SMDC | Vapam Soil Fumigant | soil disinfestation | 800 | severe |
| sulfur | many | field crops, fruit, ornamentals, vegetables | 17,000+ | none |
| streptomycin | Agrimycin, Ag-Strep Agri-Strep, Phytomycin | fruit, ornamentals, vegetables | 9,590 | mild |
| thiabendazole | Mertect, TBZ, Tecto | field crops, fruit, ornamentals, turf, vegetables | 3,100 | mild |
| thiophanate-methyl | Topsin, Fungo | field crops, fruit, ornamentals, turf | 7,500 | mild |
| thiram | Arasan, Thylate, Thiram | field crops, fruit, ornamentals, turf, vegetables | 780 | none to severe |
| Triphenyltin hydroxide | Du-Ter | vegetables | 108 | mild |
| zineb | Dithane 78, Zineb | field crops, fruit, ornamentals, vegetables | 5,200 | mild |
| ziram | Zerlate, Karbam White, Z-C | ornamentals, vegetables | 1,400 | none to severe |

***Table 3. Chemical Class, Uses, Oral $LD_{50}$, Worker Reentry Time, and Toxicity of Common Insecticides***

| Insecticide | Trade name | Chemical class | Uses | Oral $LD_{50}$ | Toxicity to mammals | | Worker reentry time | Toxicity to | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Acute oral | Acute dermal | | birds | fish | bees |
| acephate | Orthene | OP | ornamentals | 361 | moderate | moderate | * | moderate | low | NA |
| aldrin | | CH | (not manufactured for ag. use) | 39-60 | high | high | * | high | high | high |
| Aramite | | M | ornamental | 3,900 | low | NA | * | low | moderate | low |
| azinphosmethyl | Guthion | OP | crop | 11 | high | moderate | 1 day | moderate | NA | high |
| *Bacillus thuringiensis* | | LO | crop | — | very low | very low | * | very low | very low | very low |
| bidthion | Abate | OP | mosquito larvicide | 1,000 | low | moderate | * | moderate | low | NA |
| carbaryl | Sevin | C | general | 500 | low | low | * | low | very low | high |
| carbofuran | Furadan | C | crop | 8 | high | low | * | high | NA | NA |
| carbophenothion | Trithion | OP | crop | 10 | high | high | 2 days | NA | NA | moderate |
| chlordane | | CH | general | 335 | moderate | moderate | * | moderate | high | high |
| chlorpyrifos | Dursban | OP | general | 97 | moderate | moderate | * | moderate | NA | NA |
| coumaphos | Co-Ral | OP | livestock | 15 | high | moderate | * | moderate | NA | moderate |
| crotoxyphos | Ciodrin | OP | livestock | 125 | moderate | moderate | * | NA | NA | high |
| crufomate | Ruelene | OP | livestock | 460 | moderate | low | * | NA | NA | NA |
| DDT | | CH | illegal to use | 113 | moderate | low | * | moderate | high | moderate |
| DEET | many | M | insect repellent | 1,950 | low | low | * | NA | NA | NA |
| demeton | Systox | OP | crop | 2 | high | high | 2 days | moderate | moderate | low |
| diazinon | | OP | general | 76 | moderate | moderate | * | moderate | high | high |
| dichlorvos | DDVP | OP | general | 56 | moderate | high | * | NA | moderate | high |
| dicofol | Kelthane | CH | general (miticide) | 1,000 | low | moderate | * | low | high | low |
| dieldrin | | CH | (not manufactured for ag. use) | 46 | high | high | * | high | high | high |
| dimethoate | Cygon | OP | general | 215 | moderate | moderate | * | moderate | low | high |
| disulfoton | Di-Syston | OP | crop | 2 | high | high | * | moderate | NA | moderate |
| endosulfan | Thiodan | CH | crop | 18 | high | high | * | low | NA | moderate |
| endrin | | CH | crop | 8 | high | high | 2 days | high | high | moderate |
| EPN | | OP | crop | 8 | high | high | 1 day | moderate | NA | high |
| ethion | | OP | crop | 27-65 | high | high | 1 day | NA | NA | low |
| ethoprop | Mocap | OP | corn soil | 62 | high | high | * | moderate | NA | NA |
| fensulfothion | Dasanit | OP | corn soil | 2 | high | high | * | high | NA | NA |
| fenthion | Baytex | OP | household, livestock | 215 | moderate | moderate | * | high | low | high |
| fonofos | Dyfonate | OP | crop | 16 | high | high | * | moderate | NA | NA |
| heptachlor | | CH | general | 100 | moderate | high | * | moderate | high | high |
| lead arsenate | | A | crop | 1,050 | low | low | * | NA | NA | high |
| lindane | | CH | general | 88 | moderate | moderate | * | moderate | high | high |
| malathion | | OP | general | 1,000 | low | low | * | low | high | high |
| methidathion | Supracide | OP | crop | 25-65 | high | moderate | * | NA | NA | NA |
| methomide | Monitor | OP | crop | 18 | high | high | * | NA | NA | NA |
| methomyl | Lannate | C | vegetables | 17 | high | moderate | * | low | NA | NA |
| methoxychlor | | CH | general | 5,000 | low | low | * | low | high | low |
| methyl parathion | | OP | crop | 14 | high | high | 2 days | high | low | high |
| mevinphos | Phosdrin | OP | crop | 4 | high | high | * | NA | NA | high |
| naled | Dibrom | OP | general | 250 | moderate | moderate | * | low | high | high |
| nicotine | | B | crop | 83 | moderate | moderate | * | NA | low | low |
| parathion | | OP | crop | 4 | high | high | 2 days | moderate | high | high |
| phorate | Thimet | OP | crop | 1 | high | high | * | moderate | NA | moderate |
| phosmet | Imidan | OP | general | 147 | moderate | low | * | moderate | NA | NA |
| propoxur | Baygon | C | household, turf | 95 | moderate | moderate | * | moderate | NA | NA |
| pyrethrin | | B | household, livestock | 820 | low | moderate | * | NA | high | low |
| ronnel | Korlan | OP | livestock | 1,250 | low | low | * | NA | NA | NA |
| rotenone | | B | crop | 50-75 | moderate | moderate | * | NA | high | low |
| stirifos | Rabon | OP | livestock | 4,000 | low | low | * | moderate | NA | NA |
| terbufos | Counter | OP | corn soil | 4 | high | high | * | high | high | NA |
| toxaphene | | CH | general | 80 | moderate | moderate | * | moderate | high | low |
| trichlorfon | Dylox | OP | general | 560 | low | low | * | moderate | low | low |

$LD_{50}$ = Based on technical product.
A = arsenical; B = botanical; C = carbamate; CH = chlorinated hydrocarbon; LO = living organism; M = miscellaneous; OP = organic phosphate.
NA = Not available.
* = Worker cannot enter a treated field without protective clothing until the spray has dried or the dust has settled.

*Table 4. Chemical Class, Oral $LD_{50}$, and Dermal Toxicity and Irritation of Common Herbicides*

| Common name | Trade name | Chemical class | Oral $LD_{50}$ (mg/kg) | Dermal toxicity | Dermal irritation | Toxicity to fish |
|---|---|---|---|---|---|---|
| acrolein | Aqualin | acryaldehyde | 46 | high | severe | high |
| alachlor | Lasso | acetanilide | 1,200 | low | mild | moderate |
| ametryn | Evik | s-triazine | 1,100 | low | mild | low |
| amitrole | many | triazole | 14,700 | low | mild to moderate | low |
| AMS | Ammate-X | inorganic | 3,900 | low | mild | low |
| atrazine | AAtrex, Atratol | s-triazine | 3,080 | low | mild | low |
| benefin | Balan | dinitroaniline | 5,000+ | low | mild | low |
| bensulide | Betasan, Prefar | benzosulfonamide | 770 | low | mild | moderate |
| bentazon | Basagran | benzothiadiazone | 1,100 | low | moderate | low |
| bifenox | Modown | diphenyl ether | 10,000 | low | moderate | moderate |
| bromacil | Hyvar X | uracil | 5,200 | low | mild | low |
| bromoxynil | Brominal, Buctril | benzonitrile | 260-440 | moderate | moderate | high |
| butralin | Amex | dinitroaniline | 2,500 | low | mild | moderate |
| butylate | Sutan+ | thiocarbamate | 3,880 | low | mild | low |
| calcium arsenate | many | inorganic arsenical | 35-110 | moderate to high | moderate | moderate |
| chloramben | Amiben, Vegiben | benzoic acid | 3,500 | low | mild | low |
| chlorbromuron | Maloran | phenylurea | 2,150 | low | moderate | low |
| chloroxuron | Tenoran | phenylurea | 3,700 | low | mild | low |
| chlorpropham | Furloe Chloro IPC | phenylcarbamate | 3,800 | low | mild | low |
| cyanazine | Bladex | s-triazine | 334 | low | mild | low |
| 2,4-D | many | phenoxy acid | 375-1,000 | low | mild | low to moderate |
| 2,4-DB | Butozone, Butyrac | phenoxy acid | 500 | low | mild | low to moderate |
| dalapon | Basfapon, Dowpon | proprionic acid | 7,570 | low | moderate | low |
| DCPA | Dacthal | phthalic acid | 3,000 | low | mild | low |
| dicamba | Banvel | benzoic acid | 1,040 | low | mild | low |
| dichlobenil | Casoron | benzonitrile | 3,160 | low | mild | low |
| dinitramine | Cobex | dinitroaniline | 3,700 | low | mild | moderate |
| dinoseb | Premerge | dinitrophenol | 40-58 | moderate | moderate | high |
| diphenamid | Dymid, Enide | phenylamide | 590 | low | mild | low |
| diquat | Diquat | pyridilium | 230 | moderate | moderate | low |
| diuron | Karmex | phenylurea | 3,400 | low | mild | low |
| endothall | Aquathol, Endothal Hydrothol | phthalic acid | 182-206 | moderate | moderate | low |
| DSMA, MSMA | many | organic arsenical | 700-1,800 | moderate | mild to moderate | low |
| EPTC | Eptam, Eradicane | thiocarbamate | 1,370 | low | mild | low |
| fluchloralin | Basalin | dinitroaniline | 1,550 | low | moderate | moderate |
| glyphosate | Roundup | phosphonoglycine | 4,900 | low | moderate | low |
| linuon | Lorox | phenyurea | 1,500 | low | mild to moderate | low |
| mecoprop | many | phenoxy acid | 700 | low | mild | low to moderate |
| MCPA | many | phenoxy acid | 700-800 | low | mild | low to moderate |
| metolachlor | Dual | acetanilide | 2,780 | low | mild | low |
| metribuzin | Lexone, Sencor | as-triazine | 1,940 | low | mild | low |
| monuron-TCA | Urox | phenylurea-TCA | 2,300 | low | moderate | low |
| naptalam | Alanap | phthalic acid | 1,700 | low | mild | low |
| nitrofen | TOK | diphenyl ether | 1,470 | low | mild to moderate | low |
| oryzalin | Surflan | dinitroaniline | 10,000 | low | mild | moderate |
| paraquat | Paraquat | pyridilium | 120 | moderate | moderate | low |
| pendimethalin | Prowl | dinitroaniline | 1,050 | low | mild | moderate |
| picloram | Tordon | picolinic acid | 8,200 | low | mild | low |
| profluralin | Tolban | dinitroaniline | 2,200 | low | mild | moderate |
| prometone | Pramitol | s-triazine | 2,980 | low | mild | low |
| pronamide | Kerb | benzamide | 5,620 | low | mild | low |
| propachlor | Bexton, Ramrod | acetanilide | 710 | low | moderate | low |
| propazine | Milogard | s-triazine | 5,000+ | low | mild | low |
| siduron | Tupersan | phenylurea | 5,000 | low | mild to moderate | low |
| silvex | Kuron, 2,4,5-TP | phenoxy acid | 650 | low | moderate | moderate |
| simazine | Aquazine, Princep | s-triazine | 5,000 | low | mild | low |
| sodium arsenite | many | arsenical | 10-50 | high | moderate | moderate |
| sodium borate | many | inorganic borout | 2,000 | low | mild to moderate | low |
| sodium chlorate | many | inorganic | 5,000 | low | moderate | moderate |
| TCA | Sodium TCA | acetic acid | 5,000 | low | moderate | low |
| 2,4,5-T | many | phenoxy acid | 300 | moderate | mild | low to moderate |
| terbacil | Sinbar | uracil | 5,000+ | low | mild | low |
| terbutryn | Igran | s-triazine | 2,400 | low | mild | low |
| trifluralin | Treflan | dinitroaniline | 3,700 | low | mild | moderate |
| vernolate | Surpass, Vernam | thiocarbamate | 1,800 | low | mild | low |

# CHAPTER TWO: HUMAN PESTICIDE POISONING

Although pesticides are designed to control pests, they are also toxic (poisonous) to desirable plants and animals, including humans. Many pesticides are so highly toxic that very small quantities can kill a person, and exposure to a sufficient amount of almost any pesticide can make a person ill. Even the fairly safe pesticides can irritate the skin, eyes, nose, or mouth.

Experience has shown that accidents are most likely to occur:

(1) At the beginning of the season when inexperienced personnel are handling the chemical.

(2) When a new pesticide is brought on the market.

(3) During the first prolonged hot spell of the season. Operators run the risk of overexposure by removing uncomfortable protective clothing and respirators during hot weather.

(4) Late in the season, especially if the work load has been prolonged. The effects of exposure to pesticides may be cumulative. Workers who have been exposed repeatedly to pesticides throughout the season without acquiring obvious symptoms may suddenly become ill through additional exposure.

## EXPOSURE TO PESTICIDES

When an operator is doused with a pesticide or swallows some pesticide and immediately loses consciousness, there is no doubt about the cause of the illness, and proper medical treatment should be administered as soon as possible. "One-time" cases like this are examples of **acute exposure.**

**Chronic exposure** is a low-level exposure over a longer period of time. The effect is a mild, slow poisoning. The symptoms are less severe than in acute cases, and are often difficult to isolate as having been caused by pesticides.

Chronic exposures can be as dangerous as acute exposures. The greatest risk when working with a pesticide is a combination of chronic and acute exposure. If you have been receiving daily exposure (from a contaminated hat or shoes, for example), your body will be less able to deal with an acute exposure (such as spilling pesticide on yourself).

Before a pesticide can harm you, it must be taken into the body orally (through the mouth and digestive system); dermally (through the skin); or by inhalation through the nose and respiratory system. Both acute and chronic exposure can result from pesticides entering your body through any of these routes.

### Oral Exposure

Oral exposure may occur because of an accident, but it is more likely to be the result of carelessness. Blowing out a plugged nozzle with your mouth, smoking or eating without washing contaminated hands, or eating fruit that has been recently sprayed with a pesticide can result in oral exposure. The seriousness of the exposure depends upon the oral toxicity of the material and the amount swallowed.

Acute oral toxicity is expressed by the $LD_{50}$ value. There is some uncertainty about applying $LD_{50}$ values from tests on rabbits or rats to predict the toxicity of a particular pesticide to humans. Most experts agree, however, that the *relative* toxicities probably are about the same for humans as for rats.

If you know the $LD_{50}$ of a pesticide, you can estimate the amount likely to cause death (probable lethal dose) by using the following formula:

$$LD_{50} \times .0016 \times \frac{\text{body weight (pounds)}}{100} = \text{ounces of pesticide.}$$

For example, Malathion has an $LD_{50}$ of 1,375 milligrams per kilogram of body weight.

**1,375 × .0016 = 2.2 ounces per 100 pounds of body weight.**

A person weighing 100 pounds who swallows 2.2 ounces of Malathion would have about a 50-percent chance of surviving. A person weighing 150 pounds can tolerate 50 percent more Malathion than the 100-pound person.

$$\text{Probable lethal dose} = 2.2 \text{ ounces} \times \frac{150 \text{ pounds}}{100}$$

$$= 3.3 \text{ ounces of pesticide.}$$

A 50-pound child would need to be exposed to only 1.1 ounces of Malathion to have a 50-percent chance of surviving.

The acute oral $LD_{50}$ ratings shown below range from extremely hazardous to slightly hazardous. The probable lethal dose for a 150-pound adult varies from a few drops to more than 2 pounds.

| Acute oral $LD_{50}$ | Probable lethal dose, 150-pound adult |
|---|---|
| 5 | few drops |
| 50 | 1 teaspoonful |
| 500 | 2 tablespoonsful |
| 1,500 | 1 pound |
| 5,000 | 2 pounds |

### Dermal Exposure

Dermal exposure is skin contamination. It can occur any time a pesticide is mixed, applied, or handled, and it is often undetected. Its seriousness depends upon (1) the dermal toxicity of the material; (2) the rate of absorption through the skin; (3) the size of the skin area contaminated; and (4) the length of time the material is in contact with the skin. Like oral exposure, dermal exposure can be expressed as an $LD_{50}$ value.

Rates of absorption through the skin are different for different parts of the body. Using absorption through the forearm (1.0) as the standard, absorption is over 11 times faster in the lower groin area. Absorption through the skin in the scrotal area is rapid enough to approximate the effect of injecting the pesticide directly into the bloodstream. At this rate, the absorption of pesticide through the skin into the bloodstream is more dangerous than swallowing it.

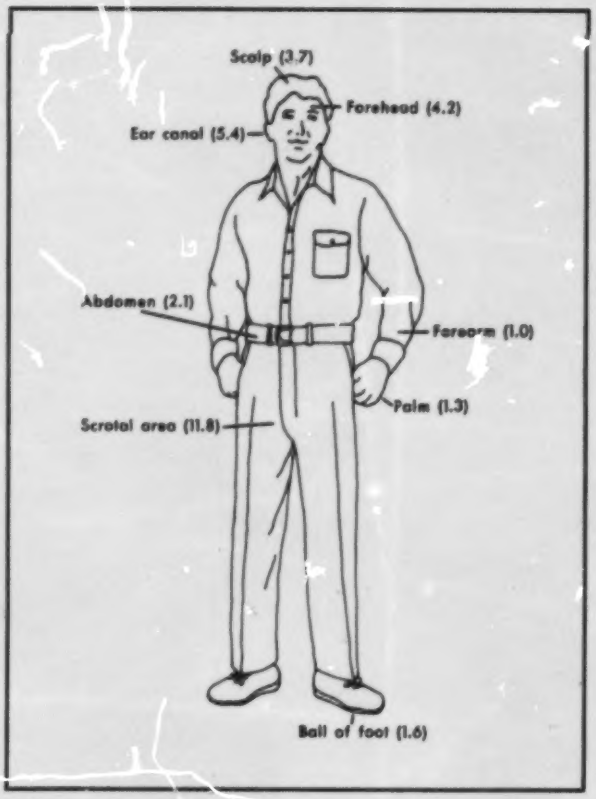
You should also be aware that it is not only the pesticide that is dangerous. Many pesticides are carried in oil-based materials. If this oil gets into the bloodstream, the results can be fatal. The oil crosses the skin barrier as rapidly as the pesticide in highly sensitive parts of the body. Wear rubber aprons or rubber trousers to protect the lower parts of the body.

Absorption continues to take place through all of the affected skin area as long as the pesticide is in contact with the skin. The seriousness of the exposure is increased if the contaminated area is large, or if the material remains on the skin for a long period of time.

### Inhalation Exposure

Inhalation exposure results from breathing in pesticide vapors, dust, or spray particles. Like oral and dermal exposure, inhalation exposure is more serious with some pesticides than with others.

Poisoning through the lungs is more common in confined areas such as greenhouses than it is outdoors because the pesticide is kept inside the structure. Poisoning can occur outdoors if the concentration of material is high or a highly volatile material is used.




Dermal absorption rates as compared with the forearm.

Inhalation exposure can occur from the applicator smoking; breathing smoke from burning containers; breathing fumes from pesticides while applying them without protective equipment; and inhaling fumes immediately after applying a pesticide.

## SYMPTOMS OF PESTICIDE POISONING

Children under 10 years of age are the victims of at least one-half of the accidental deaths caused by pesticides in the United States. Nearly all pesticide deaths, in both children and adults, are caused by eating or drinking the product. Some pesticide applicators are killed when they breathe a pesticide or get it on their skin, but deaths from occupational exposure are now unusual.

You should be aware of the early symptoms of poisoning. It is important to remove the poisoned person from the source of exposure quickly. Contaminated clothing should be removed, and any pesticide that has soaked through should be washed off.

The symptoms of pesticide poisoning are similar to those of other types of poisoning and of other diseases. Heat exhaustion, food poisoning, asthma, and other

illnesses are sometimes confused with pesticide poisoning. The fact that a pesticide applicator becomes ill after using or being around pesticides is not proof that he has been poisoned by them.

The symptoms of poisoning may occur in an applicator who has been suddenly exposed to large quantities of a toxic material. Or they may occur in an applicator who has been continually exposed to small quantities of a pesticide over longer periods of time.

Each class of pesticide produces the same set of symptoms. The poisoning may be so mild that it can scarcely be detected, or it may become increasingly severe, depending upon the dose absorbed. One or more symptoms (headache, feeling of being unwell, etc.) may be common to many kinds of illnesses, whether caused by poisons or by viruses, bacteria, etc. It is not one or two symptoms, but the *pattern* of symptoms that makes it possible to tell one kind of sickness from another. Some clues to pesticide poisoning are sensations that only the applicator is aware of, such as nausea or headache; others, like an ashen skin color, can be noticed by someone else.

**Poison treatment centers** have been established at various locations in Illinois to provide pertinent information on all types of poisoning, including pesticide poisoning. These centers and their telephone numbers are listed in Appendix I. Give your doctor the telephone number of the poison treatment center nearest you, and tell him what pesticides you will be using. He can then determine the poisoning symptoms and appropriate treatment and have antidotes on hand if a poisoning should occur.

You should get medical advice quickly if you or any of your fellow workers have unusual or unexplained symptoms while at work or later in the day. Do not allow yourself or anyone else to become dangerously ill before calling a doctor or going to a hospital. It is better to be too cautious than too late. If you believe that you may have been poisoned, be sure to take the pesticide container (or label) to the doctor.

## Organophosphates

The organophosphates are involved in more cases of occupational poisoning and deaths than any other single group of pesticides. The symptoms of poisoning by organophosphates progress through several stages.

The usual sequence of symptoms for **mild poisoning** is as follows: fatigue; headache; dizziness; numbness in the arms or legs; nausea and vomiting; excessive sweating and salivation; and abdominal cramps or diarrhea.

In **moderate poisoning**, the symptoms listed for mild poisoning become more severe. Additional symptoms for moderate poisoning include inability to walk; generalized weakness; difficulty in talking; muscular twitches; and contraction of the pupil of the eye.

The symptoms for **severe poisoning** are unconsciousness; severe contraction of the pupil of the eye; muscular twitches; secretions from the mouth and nose; and respiratory difficulty. If victims of severe poisoning are not treated immediately, death will usually result.

Illness is frequently delayed several hours, and an applicator may first become sick at home after supper. If symptoms begin more than 12 hours after the last known exposure to the pesticide, illness is probably due to some other cause.

## Carbamates

The carbamates likely to cause illness through occupational exposure act in the same way as the organophosphates, and produce the same type of poisoning symptoms. The illness caused by carbamates is usually not as severe or as enduring, however, and they are generally considered safer than the highly toxic organophosphates.

## Chlorinated Hydrocarbons

Only a few organochlorines have caused occupational poisoning. Several of them are regularly stored in the body tissues, however, and may accumulate in considerably higher concentrations in pesticide applicators than in the general population.

Early symptoms of poisoning include headache, nausea, vomiting, general discomfort, and dizziness. With more severe poisoning, convulsions follow or may appear without these early warning symptoms. Coma may follow the convulsions. Excessive excitability and irritability are common symptoms.

## Metals and Metalloids

The metallic pesticides that cause the most poisonings in the United States are those containing arsenic. Large single doses of most heavy metal pesticides cause vomiting and stomach pain. The exact nature of the symptoms varies with the metal, but in all cases the illness is chronic.

## Cyanide

Cyanide is one of the fastest-acting poisons. Massive doses result in unconsciousness and death without warning. Smaller doses may result in the odor of bitter almonds on the breath, salivation, nausea, anxiety, confusion, and dizziness. Illness may last one or more hours, terminating with unconsciousness, convulsions, and death from respiratory failure.

### Anticoagulants

The injurious effects of anticoagulants are due to loss of blood, mainly into the body tissues. For example, the initial symptoms in chronic warfarin poisoning are back pain and abdominal pain.

### Fluoroacetates

Poisoning from fluoroacetates (1080, for example), causes stimulation of the central nervous system, resulting in convulsions and abnormal heart rhythm.

### Dinitrophenols

The symptoms of poisoning by one or a few relatively large doses of the dinitrophenols (Elgetol, for example) include headache, nausea, gastric distress, restlessness, a sensation of heat, flushed skin, sweating, deep and rapid respiration, fast beating of the heart, fever, ashen color, collapse, and coma. Acute poisoning with DNOC usually runs a rapid course. Death or almost complete recovery within 24 to 48 hours is the general rule.

### Bromides and Carboxides

The symptoms of excessive exposure to the less toxic bromides and carboxides are those of drunkenness, such as poor coordination, confusion, and sleepiness. Rapid removal to fresh air is important. Methyl bromide is extremely dangerous because a toxic or even fatal dose can be absorbed before symptoms appear.

### Pyridiliums

Pyridilium herbicides (paraquat, for example) may be harmful if inhaled or absorbed through the skin and may be fatal if swallowed. Lung fibrosis can develop if paraquat is swallowed or inhaled. The symptoms of injury may be delayed. Prolonged skin contact will cause severe irritation.

## TREATMENT OF PESTICIDE POISONING

First aid is the initial effort to help a victim while medical help is on the way. The first step in any poisoning emergency is to call an ambulance or doctor except when you are alone with the victim. Then you must make certain that the victim is breathing and is not further exposed before calling an ambulance or a doctor. The label of the pesticide responsible for the poisoning should always be saved for the doctor.

While waiting for the ambulance or doctor, you should follow the proper first-aid procedures for poison on the skin, poison in the eyes, inhaled poison, or swallowed poison. These procedures are described below.

### Poison on the Skin

Drench the victim's skin and clothing with water. The faster the poison is washed off, the less injury will result. In an emergency, any source of fairly clean water, such as irrigation canals, lakes, ponds, water troughs, etc., should be used. Don't let the victim die while you worry about how dirty the water is.

Remove the victim's clothing, and clean his skin and hair thoroughly with soap and water. Detergents and commercial cleansers are better than soap for this purpose.

Wash the burn area with large quantities of running water, and cover immediately with a clean, soft cloth. Do not use ointments, greases, powders, or drugs in first-aid treatment of burns. Be careful not to get any pesticide on yourself while you are helping the victim.

### Poison in the Eyes

It is most important to wash the eyes out as quickly but as gently as possible. Holding the victim's eyelids open, wash his eyes with a gentle stream of clean, running water for 15 minutes or longer. Do not use chemical or drugs in the wash water — they increase the extent of the injury.

### Inhaled Poison

If the victim is in an enclosed space, do not go in after him without an air-supplied respirator. Open all doors and windows. Carry the victim (do not let him walk) into the fresh air immediately.

Loosen the victim's clothing. Apply artificial respiration if his breathing has stopped or is irregular, and keep him as quiet as possible.

If the victim is convulsing, watch his breathing and protect him from falling and striking his head. Keep his chin up so that his air passage will remain free for breathing. Prevent chilling. Wrap the victim in blankets but don't allow him to become overheated.

### Swallowed Poison

The best first-aid treatment for a person who has swallowed a pesticide is to give him large amounts of plain water or milk. Give 1 to 2 cups for victims up to five years of age, and up to 1 quart for victims five years old and older. Milk is preferable to water because it both dilutes and helps neutralize the poison. Water simply dilutes the poison. Diluting the poison will often be sufficient treatment until you can get the victim to a hospital.

If it is necessary to induce vomiting, make sure that the victim is lying face down or kneeling forward while

retching or vomiting. Do not allow him to lie on his back — vomitus could enter his lungs. Put your finger or the blunt end of a spoon at the back of the victim's throat. Do not use anything sharp or pointed. A glass of soapy water or strong salt water will also cause the victim to vomit. Collect some of the vomitus for the doctor. He may need it for chemical tests.

You should *never* induce vomiting under the following conditions:

(1) **If the victim is unconscious or is in convulsions.** The victim could choke to death on the vomitus.

(2) **If the victim has swallowed a corrosive poison.** Find out what poison the victim has swallowed. A corrosive poison is a strong acid or alkali. If poisoned by these chemicals, the victim will complain of extreme pain and have severe mouth and throat burns. A corrosive poison will burn the throat and mouth as severely coming up as it did going down.

(3) **If the person has swallowed a concentrated petroleum product** (kerosene, gasoline, oil, lighter fluid, etc.). Most pesticides in liquid formulations are dissolved in petroleum products. The words "emulsifiable concentrate" or "solution" on the pesticide label are signals *not* to induce vomiting if the victim has swallowed the concentrate. Concentrated petroleum products, like corrosive poisons, cause severe burns. If the victim has swallowed a dilute form of these formulations, however, he should be forced to vomit immediately.

In addition to diluting the poison with milk or water (and, in some cases, inducing vomiting), you may give the victim one of the following **universal antidotes** to neutralize the effects of the poison.

**For acids only.** If you are sure that the poison is an acid, give the victim milk of magnesia (1 tablespoon to 1 cup of water), baking soda, or chalk in water.

**For alkali only.** If you are sure that the poison is an alkali, give the victim lemon juice or vinegar.

**For concentrated petroleum products.** Dilute with milk or water *only*.

**Universal sponges** that absorb excess poisons are recommended in cases where the type of poison swallowed is unknown. Activated charcoal (such as that used in aquarium filters) is a universal sponge that absorbs many poisons at a high rate. Mix it with water into a thick soup for the victim to drink. Grosafe, a commercial preparation of activated charcoal, is sold for use on pesticide spills or overdoses on crops and soil. In a poisoning emergency, this product may be substituted for a pharmaceutical grade of activated charcoal.

A homemade universal sponge for poison is a mixture of 4 tablespoons of toast (burnt black), 2 tablespoons of strong tea (instant tea mix can be used), and 2 tablespoons of milk of magnesia. This mixture will absorb and neutralize most poisons.

## Medical Antidotes

Medical antidotes are also available to neutralize the poisoning effects of a few other pesticides. Taken improperly, however, these antidotes can be more dangerous than the effects of the pesticide itself. Medical antidotes should be prescribed or given only by a physician. There are no known antidotes for many pesticides. Once a lethal dose has been ingested, the effects are irreversible and terminal.

Any pesticide applicator working with highly toxic carbamate and organophosphate pesticides should have his **cholinesterase** level tested at regular intervals throughout the spray season. Cholinesterase is necessary for the nervous system, and the poison victim will die without it. Both carbamate and organophosphate pesticides attack this chemical in the blood and make it useless.

After a physician has determined the applicator's base level of cholinesterase, a simple blood test will show if this level has decreased. If the cholinesterase level has decreased, the applicator has been overexposed to either an organophosphate or carbamate pesticide. He should avoid further contact with these pesticides until his cholinesterase level has returned to normal. In severe cases, medical antidotes must be given.

Atropine sulfate and protopam chloride (2-PAM) can be used to counteract the effects of organophosphates. Atropine sulfate can also be used to treat poisoning from carbamates; however, 2-PAM *cannot* be used for this purpose.

# CHAPTER THREE: SAFE HANDLING OF PESTICIDES

Exposure to pesticides can occur in transporting, storing, mixing, and loading pesticides; applying pesticides; working in treated crops; cleaning application equipment after use; disposing of used pesticides and empty containers; and clearing up pesticide spills and protective clothing and equipment.

## PROTECTIVE CLOTHING AND EQUIPMENT

Pesticides can enter the body through many routes. The most common is through skin contact. To prevent absorption through the skin, the applicator must wear a protective barrier. No safety recommendations can cover all situations. Always read the pesticide label for recommendations on the use of protective clothing and safety devices.

### General Protection

When using any pesticide, wear at least a hat, long-sleeved shirt, and longlegged trousers or a coverall garment (all of closely woven fabric). When handling pesticide concentrates during mixing and loading, or when using highly or moderately toxic materials, you should also wear rubber gloves, a rubber apron, and goggles. Trousers and sleeves should be worn *outside* of boots and gloves to prevent pesticides from getting inside.

If you will be working in a mist, or your clothes will become wet for any reason, wear a waterproof suit. If it is too hot for a heavy rubber rainsuit, wear a lightweight, disposable waterproof suit.

### Gloves

Unlined liquid-proof gloves (rubber or neoprene) should be worn when handling a pesticide concentrate or using organophosphates, carbamates, or other chemicals with the signal words "Danger-Poison" or "Warning" on the label. Some fumigants are readily absorbed by neoprene. Check the label for the proper gloves to use. Cotton or leather gloves should never be worn. They absorb the pesticide and hold it close to the skin for long periods of time, and can be more hazardous than not wearing gloves at all. Before removing gloves, wash them with detergent and water to prevent contaminating your hands.

### Boots

Lightweight, unlined rubber boots should be worn when handling or applying highly or moderately toxic pesticides. The boots should be washed often and dried thoroughly inside and out to remove any pesticide residue.

### Goggles or Face Shield

Wear tight-fitting, nonfogging goggles or a full face shield whenever there is a chance of getting pesticides in your eyes. You should wear this equipment when pouring or mixing concentrates or working in a highly toxic spray or dust. Since most headbands absorb pesticides, wear the headband under the head covering.

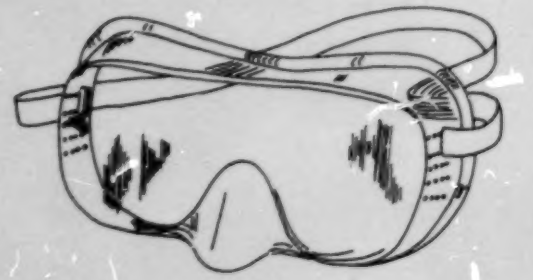
### Head and Neck Coverings

The hair and skin on your neck and head must also be protected. Rubber or plastic rainhats, wide-brimmed hats, billed caps, and hard hats that can be washed are satisfactory. In cool weather, waterproof parkas with hoods and a billed cap are also acceptable. The headgear should not have a cloth or leather sweatband, since these bands are difficult to clean. Do not wear cotton or felt hats.

### Care of Clothing and Equipment

Wear a clean set of clothing each day that you spray. If fabrics become wet with dilute spray during the day, they should be changed. If clothes get wet with liquid concentrates or highly toxic pesticides, they should be discarded. They are difficult to clean thoroughly by normal methods. Contaminated clothing should not be stored or washed with the family laundry. Gloves and boots should be washed daily. Test gloves for leaks by filling them with water and squeezing gently.

Wash goggles or face shields at least once a day. Fabric headbands absorb pesticides and are difficult to clean. Have several spare headbands available so that they can be replaced frequently, or use a rubber strap.



Goggles

## RESPIRATORS

Respirators provide protection from inhaling toxic chemicals. They should be worn whenever the more toxic organophosphate (TEPP, parathion, Guthion, Di-Syston, Thimet, Phosdrin) or carbamate (Furadan, Temik) pesticides are applied. The label will indicate if a respirator is needed. Respirators are especially necessary in mixing and handling concentrated, highly toxic pesticides.

An applicator who will be constantly exposed to small amounts of toxic pesticides for long periods of time, or who will be working in an enclosed area, should also wear a respirator. It should be worn tightly enough to form a seal around the face. If the headband is too tight, headaches and dizziness may result.

### Chemical Cartridge Respirator

In a chemical cartridge respirator, inhaled air comes through both a filter pad and a cartridge of activated charcoal. Most harmful vapors, gases, and particles are removed. These half-face masks cover the mouth and nose. For eye protection, you should also wear goggles.

### Chemical Canister Respirator (Gas Mask)

Gas mask canisters contain more and longer lasting absorbing material and filters than cartridge respirators. A gas mask should be worn when mixing or applying toxic pesticides in enclosed or poorly ventilated areas. Gas masks usually protect the face better than cartridge types, and may leak less because they fit more tightly. A chemical respirator will not protect you when the oxygen supply is low, as in a silo.

### Supplied-Air Respirator

A supplied-air respirator should be worn when the oxygen supply is low, or when the applicator is exposed to high concentrations of very toxic pesticides in enclosed areas. Fresh air is pumped through a hose to the face mask. In some units, the applicator carries the oxygen supply with him in a cylinder.

### Care and Maintenance

Certain types of cartridges and canisters protect against specific chemical gases and vapors. Be sure to choose the type made to protect against the pesticides

Chemical Cartridge Respirator

Chemical Canister Respirator (Gas Mask)

you will use. The respirator must fit the face well to insure a good seal. Long sideburns, a beard, or glasses may prevent a good seal.

During heavy spraying, the filters in chemical cartridge respirators should be changed two or more times a day if breathing becomes difficult. Cartridges should be changed after eight hours' use, or sooner if the applicator detects pesticide odor. Filters and cartridges should be removed after each use. The facepiece should be washed with soap and water, rinsed, dried with a clean cloth, and stored in a clean, dry place away from pesticides. A tightly closed plastic bag works well for storage.

The useful life of a cartridge or canister depends upon the type and amount of chemical fill, the concentration of contaminants in the air, the breathing rate of the wearer, and the temperature and humidity. The manufacturer's instructions on the use and care of a respirator and its parts should be read carefully before using the respirator. Only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) or the U.S. Bureau of Mines should be used.

## MIXING AND LOADING PESTICIDES

Some pesticides are used exactly as purchased. These include baits, garden dusts, granular materials, pesticides contained in pressurized cans, and certain liquid household and livestock sprays. Most applicators, however, will purchase concentrated pesticides, such as wettable powders or emulsifiable concentrates, that must be diluted with other liquids (usually water) before they can be used.

Before handling a pesticide container, put on the correct protective clothing and other necessary protective equipment. Each time you use a pesticide, carefully read the directions for mixing before removing the material from the container. This precaution is essential, since directions, including amounts and methods, are changed periodically.

Of the various work activities associated with pesticide use, mixing and loading is the most hazardous part of the spraying or dusting cycle. The mixing and loading of pesticides usually result in exposure to a mix of higher concentration and in larger quantities than diluted pesticides.

An operator may spill pesticides on his clothing where they may soak through to the skin, or expose the person who may handle the clothing later. He may breathe particles from highly concentrated wettable powders or from granules or dusts. He may contaminate his hands, and then unintentionally carry the pesticide to his mouth when smoking, eating, or simply rubbing his lips or eyes. It is especially important that all safety precautions called for on the label be followed during mixing and filling. Wear rubber gloves, a rubber apron, goggles, and a respirator when handling moderately toxic materials, even if the label doesn't specifically recommend their use.

Pesticides should be mixed out-of-doors in a place where there is good light and ventilation. If you mix or load pesticides indoors or at night, work where there is good lighting and air circulation. Do not work alone when handling highly toxic pesticides.

When pouring or dumping any concentrated pesticide from the container, keep the container below eye level to avoid a splash or spill on goggles or protective clothing. Measure the pesticide in clean containers, and thoroughly wash the containers after use. Open concentrate containers carefully. Open paper containers with a knife rather than tearing them. Always stand upwind when mixing or loading pesticides.

The environment is also easily harmed by careless mixing and filling practices. If suction hoses are not equipped with good antisiphoning devices such as check valves, the spray mixture from the tank may escape down the hose into the water source, stream, pond, or well. If the applicator allows the tank to run over when filling, the overflow carrying pesticides will usually end up in the water source or as toxic puddles on the ground. Never leave a spray tank unattended while it is being filled.

If you splash or spill a pesticide while mixing or loading, stop immediately, remove contaminated clothing, and wash yourself thoroughly with soap and water. *Speed is essential.* For this reason, it is important that soap, water, and washing facilities be maintained at the mixing area.

## APPLYING PESTICIDES

A pesticide applicator is not only responsible for his own protection but also for the protection of other people, domestic animals, and the environment. You cannot afford to be careless!

### Avoid Exposure

Do not work in spray drift or runoff unless you are properly protected. Do not wipe your hands on clothing if chemicals have been spilled on your gloves. The chemicals will contaminate your clothing or may soak through to the skin. *Never* eat, drink, or smoke when handling or applying pesticides. Remember — applying even moderately toxic pesticides day after day can make you ill, and you should use proper protective clothing and equipment.

An applicator should supervise his operators to be sure that they follow all safety precautions. Always work in pairs when handling hazardous pesticides, and watch each other carefully for unusual behavior or actions. If either of you becomes sick, do not try to finish the job. Get out of the area fast and get to a doctor. Children, unauthorized people, and pets should be kept out of areas to be sprayed. They should not be allowed around sprayers, dusters, filler tanks, storage areas, or empty pesticide containers.

### Avoid Sensitive Areas

Avoid spraying near beehives, lakes, streams, pastures, houses, schools, playgrounds, hospitals, or sensitive crops whenever possible. If these areas must be sprayed, do not spray on windy days, and always spray downwind from the sensitive area.

Areas near living quarters should be sprayed in the early morning or evening when people and pets are least likely to be exposed. Notify beekeepers and residents when you plan to spray in their area, and urge them to take special precautions. Do not spray directly into or across streams, ponds, or lakes, and whenever you spray in residential areas, take every possible precaution. For example, toys and pet dishes should be removed or covered, and children should be inside.

### Avoid Drift

Do not apply chemicals when drift is likely to occur. Select application equipment, formulations, and adjuvants that will minimize drift hazard.

A good applicator carefully checks weather conditions before applying pesticides. A few simple precautions will not only protect the environment but aid the applicator financially. Pesticides that are not deposited on the target areas are wasted. More pesticide, more time, and, consequently, more money must be used to control the pests in the target area.

High winds increase drift and result in loss of the pesticide on treated areas. Drifting pesticides increase the possibility of injury to wildlife, pollinators, and domestic animals, and may settle on forage, pasture, or wildlife areas or contaminate water. Pesticide application on quiet days reduces the inhalation and contact hazard to the applicator and any bystanders.

Drift into sensitive crop areas can also be avoided by applying pesticides on quiet days. Consider early morning or evening application. Wind speed is usually lowest at these times each day, and drift hazard is greatly reduced. An applicator is legally responsible for any injury or monetary loss of crops because of pesticide drift into nontarget areas.

### Avoid Equipment Accidents

Application equipment can help an applicator use pesticides safely, but poor maintenance and careless use can add to the hazard of pesticide application. Be sure that there are no leaks in the pump or tank. Check for leaky hose connections and worn spots in hoses that could burst and splash you or others with pesticide solutions. The spray tank should have a tightly fitting lid so that neither the applicator nor others will be splashed and spray materials will not leak onto the ground.

When the tank is being filled, the applicator should stay with the sprayer. A tank that is not watched often runs over and causes pesticide to spill on the ground or into a stream. If nozzles, hoses, or lines clog, an applicator should *never* blow them out with his mouth. Even dilute spray mixtures can be toxic. To prevent spray guns from being triggered accidentally, you should always make sure that the pressure is released on the pesticide application equipment.

### Safe Reentry Time

It is dangerous for field workers to enter an area after certain pesticides have been used. The time that must pass before the area is safe to enter is known as the "reentry time." This time, which should be listed on the pesticide label, varies according to the pesticide applied and the crop or area treated. Safe reentry times have been set to allow pesticide residues to break down to low levels or to disappear completely.

An applicator should not allow farm workers, children, or other people to reenter the sprayed area until the safe reentry time has passed. Even with the safest materials, an applicator should wait at least until the spray has dried or the dust has settled. If no reentry time is shown on the label, use good judgment in allowing people to reenter sprayed areas. If an applicator must reenter an area soon after spraying, he should wear all necessary protective clothing called for on the label. (See page 7 for insecticide reentry times.)

## PESTICIDE CLEANUP

### Personal

At the end of each day, an applicator should take a shower. He should also change spray clothing daily. Contaminated clothes should be kept away from the family laundry. The pesticides on spray clothes could harm other people who touch them, and the person who will wash spray clothes should be warned of possible dangers.

### Equipment

Immediately after use, trained personnel should thoroughly clean the mixing, loading, and application equipment inside and outside. People who clean contaminated equipment should wear protective clothing, including rubber boots, a rubber apron, and goggles.

A specific area should be designated for use during cleaning operations. Preferably, the area should have a wash rack or cement apron with a well-designed sump to catch contaminated wash water and pesticides. (See page 28.)

### Spills

Despite all safety precautions, accidents can happen. If a pesticide spills in an applicator's storage area, quick action must be taken.

#### *Minor Spills*

Unauthorized people should not be permitted to get into or near any spilled pesticide. The area should be roped off or flagged to warn of possible danger. An applicator should not leave the contaminated area unless someone is present to prevent further contamination.

Anyone contaminated when the spill occurred should wash off the pesticide immediately, change clothes, and leave the contaminated area. Appropriate first-aid should be given, and a doctor should be consulted.

Spilled pesticides should be confined. If the pesticide starts to spread, it should be contained by diking it with sand or soil. The contaminated storage area should be cleared except for a small cleanup crew. The crew should wear the proper protective equipment. No one should be permitted to enter the area until it is thoroughly decontaminated.

The contaminated area should not be hosed down immediately because hosing spreads the pesticide. If the spill is liquid, then activated charcoal, absorptive clay, vermiculite, pet litter, or sawdust should be thrown over the entire spill. Enough absorbing material should be used to soak up most of the liquid. The material should then be swept or shoveled into a large leakproof drum. The area should be covered with hydrated lime, a solution of lye, ammonia, sodium hypochlorite (bleach), or strong detergent and water to neutralize the pesticide. If you are not sure what material to use, telephone the chemical manufacturer for instructions.

Finally, the area should be rinsed with plenty of water to wash away any remaining poison. The rinse water should be collected and held for proper disposal. If the spill occurred in the pesticide storage area, the area should be checked carefully to see if any other pesticides were contaminated by the spill. If so, these pesticides should also be disposed of immediately.

#### *Major Spills*

If a cleanup (decontamination) job appears too big to handle, or if there is any doubt about the correct procedure, telephone the pesticide manufacturer for assistance.

If a major pesticide spill occurs on a highway, call the state highway patrol or the local sheriff's office for assistance. An applicator should always carry the telephone numbers of these agencies on his person. Do not leave the area until responsible assistance arrives.

The National Agricultural Chemicals Association has a Pesticide Safety Team Network. This network can tell the applicator the correct decontamination procedures to use or send a local safety team to clean up the spill. An applicator can call the network toll-free anytime at (800) 424-9300.

All major pesticide spills are required by law to be reported immediately to the Illinois Environmental Protection Agency. The telephone number is (217) 782-3637. The following information should be reported:

(1) Name, address, and telephone number of person reporting.
(2) Exact location of spill.
(3) Name of company involved and location.
(4) Specific pesticide spilled.
(5) Estimated quantity of pesticide spilled.
(6) Source of spill.
(7) Cause of spill.
(8) Name of body of water involved, or nearest body of water to the spill area.
(9) Action taken for containment and cleanup.

## STORING PESTICIDES

As soon as pesticides are delivered to an applicator's property, he should store them in a locked and posted facility where children and other untrained people cannot get to them. Read the label for correct storage procedures.

### Site Selection

You need to keep several points in mind when selecting a pesticide storage area. The site should be in an area where flooding is unlikely. It should be downwind and downhill from sensitive areas such as houses, play areas, and ponds. The site should also be chosen so that runoff or drainage from the site cannot contaminate

surface or underground water. Storage facilities should be located away from human and livestock habitations to avoid or minimize contamination in case of fire.

### Storage Area

Store pesticides and pesticide containers in a separate building, room, or enclosure, depending upon the size of your pesticide inventory. If your inventory is not large enough to justify a separate building for pesticide storage, completely enclose an area on the first floor of the building. The storage area should keep the pesticides dry, cool, and out of direct sunlight.

Use an exhaust fan for ventilation in storage rooms to reduce the temperature and high concentrations of toxic fumes. Locate the fan so that exhaust will not damage plants or harm people or animals. Some pesticides require protection against freezing or extreme heat and have suitable warnings on the label. Sacks, cartons, and fiber boxes should be stored on wooden pallets or on shelves off the floor. The storage area should be securely locked. Weatherproof signs stating *Danger — Pesticides. Keep Out!* or a similar warning should be hung over every door and window.

Where large quantities of pesticides are stored, fire-resistant buildings, sprinkling systems, and fire-fighting equipment are strongly recommended. Post a list of chemicals and warning signs outside the building, and give a copy to the local fire department.

A drainage system should be built to collect any runoff water. Pesticides that may be present in tank rinsing, spills, seepage from the storage, and heavy runoff from fire-fighting or floods must be controlled. Dikes, collecting pools, and washing slabs with sumps provide a proper drainage system. All the collected runoff water should be treated as a surplus pesticide and disposed of properly.

An adequate supply of detergent or soap, hand cleanser, and water is essential in the storage area. Water is also quick first-aid in a poisoning emergency. Absorptive clay, activated charcoal, vermiculite, pet litter, or sawdust should be readily available at the storage site to soak up spills and leaks. Hydrated lime and sodium hypochlorite (Clorox or other bleach) should also be on hand to neutralize the pesticide in an emergency. A shovel, broom, dustpan, and a proper type of fire extinguisher are other essential items.

A pesticide storage area, whether it is a cabinet, room, or entire building, should be used only for pesticides and pesticide equipment. Do not store pesticides near food, feed, fertilizers, seed, veterinary medicines, or other stored products.

Glass and metal containers of liquid pesticides should be stored where they are not in the sun or near other sources of heat such as steam pipes. Heat will cause the liquid to expand so that the contents will be under pressure. When the container is opened, the pesticide may splash out on the applicator. No pesticides should be allowed to become overheated. Some formulations will catch fire if they get too hot; others lose their strength and break down when they are exposed to heat.

Store herbicides, insecticides, fungicides, etc. in separate locations within the storage area to prevent contamination and accidentally using the wrong container. In addition, all highly toxic pesticides within a particular group, such as insecticides, herbicides, etc., should be stored together in a special area so that an applicator working in that area can take special precautions to keep from being exposed.

A special area should be used for surplus pesticides and their containers while they are being held for disposal. Label these pesticides plainly, and group them according to how you plan to dispose of them. These precautions will help prevent mixups resulting in improper disposal and accidental reuse.

Store pesticides only in the original container with the label plainly visible. Pesticides should *never* be stored in anything used as a food or drink container even for a short time. Pesticides stored in a soft drink bottle, fruit jar, milk carton, etc. are a common cause of accidental pesticide poisoning. People may ask you for a small amount of the pesticide that you are using. **Restricted use** pesticides should never be given to anyone. Unless you have a small package with the manufacturer's entire label on it, you also should not give anyone **general use** pesticides.

All pesticide containers should be checked often for corrosion, leaks, and loose caps or bungs. These dangerous conditions must be corrected immediately. If containers are damaged, you should put the pesticide in a sturdy container that can be sealed. Label the new container immediately. Sometimes you can take the label from the damaged container and fasten it to the new container. Unlabeled pesticides are worthless and dangerous, since the applicator doesn't know what they are or how to use them. They should be treated as surplus pesticides held for disposal.

Do not buy more pesticide than you will need. Remove only the amount needed for one day's operation, and be sure to reseal and return any unused pesticide and empty containers to the storage area at the end of each day. Do not leave empty containers in the fields or on open dumps. Keep all empty containers in a locked storage area until they can be disposed of properly.

## DISPOSING OF PESTICIDES AND CONTAINERS

### Surplus Pesticides

Preventing a pesticide surplus is the best way to take care of a disposal problem. Always check to be sure that the pesticide is fully registered and is effective against the pest before you buy it. Estimate your needs and buy only what you need for one year. This practice will reduce carryover and the chance of spills, damaged containers, and loss of strength of the pesticide.

To avoid being faced with the disposal of a tankload of the wrong pesticide, check out the job carefully before selecting the pesticide. After you have selected the proper pesticide, mix only enough for the particular job so that you end up with an empty tank or hopper.

Despite your best efforts, however, you cannot always avoid surplus pesticides, and you must take steps to dispose of them properly. Pesticides that are in the original container or still in concentrated form may be returned to the manufacturer. Check with the manufacturing company to see if it will take back the surplus.

If you mix too much pesticide for a job or get caught with surplus pesticide mixtures, try to find other areas with the same pest problem and use up any extra tank mix or rinse water on these areas. Small amounts of surplus mixtures can be diluted and reapplied to the treated area. Extreme care must be taken, especially with herbicides, to be sure that the total application rate does not exceed the maximum rate for which the pesticide is labeled and cause excessive residues.

If it is not possible to re-treat an area, spray small amounts of extra tank mix over another area where you are sure it cannot do any harm. Clorox or lime should be added to the surplus tank mix before spraying to aid in breaking the chemical down quickly. *Do not* drain surplus pesticides in any location where they can contaminate wells, streams, lakes, or ponds.

If the manufacturer won't take back the concentrates or if you cannot use up the pesticides, you must find other safe ways to dispose of the surplus.

Federal guidelines recommend disposing of organic pesticides by incineration or by burial in specially designated landfills. Illinois does not currently have satisfactory means for disposing of large quantities of surplus pesticides, since incinerators and specially designated landfills are not readily available. Small amounts of surplus pesticides not exceeding normal household quantities can be buried in a state-approved sanitary landfill. These landfills cannot be used for disposal of large quantities of pesticides.

Landfill owners who meet environmental safety standards can obtain supplemental permits to handle toxic waste materials, including pesticides. To dispose of large quantities of surplus pesticides, contact the Illinois EPA Division of Land Pollution Control to locate the nearest landfill with a supplemental permit for toxic waste or to obtain specific instructions for disposal.

Surplus pesticides can be stored temporarily in the applicator's storage area. They should be kept in their original containers with the label intact, if possible. You can use 55-gallon steel drums with clamp covers as storage containers for smaller empty containers or surplus pesticides.

### Pesticide Containers

So-called "empty" containers are not really empty. They still contain small amounts of pesticide even after they have been rinsed properly. All empty containers, regardless of their type, should be rinsed three times before disposal. The rinse water should be dumped in the tank. Otherwise, the rinse water must be treated like a surplus pesticide and disposed of properly. Rinse water should never be dumped on the ground.

Use the following **rinse-and-drain** procedure to prepare containers for disposal:

(1) Empty the container into the spray tank and drain in a vertical position for 30 seconds.

(2) Refill the container one-fifth to one-fourth full with rinse water or other diluent.

(3) Rinse thoroughly, pour into the spray tank, and drain in a vertical position for 30 seconds.

(4) Repeat Steps 1 through 3 until the container has been rinsed three times.

Rinsed containers still have small amounts of residues in them, and should not be used for any other purpose. If used for livestock feed, water troughs, raft floats, etc., they could cause livestock poisoning or water contamination.

Separate the empty containers for disposal into the following three types:

**Type I:** combustible (burnable) containers except those that formerly contained mercury, lead, cadmium, arsenic, or inorganic pesticides.

**Type II:** noncombustible containers except those that formerly contained mercury, lead, cadmium, arsenic, or inorganic pesticides.

**Type III:** combustible and noncombustible containers that formerly contained mercury, lead, cadmium, arsenic, or inorganic pesticides.

Federal guidelines recommend that **Type I** containers be disposed of in a pesticide incinerator or buried in a specially designated landfill. However, small quantities of these containers may be burned in open fields by the

pesticide applicator when open burning is permitted by state or local regulations. Small quantities may also be buried singly in open fields with due regard for the protection of surface and subsurface water.

Open-burning regulations in Illinois permit open burning of containers provided that the containers are burned on the premises where they were used, that they are burned more than 1,000 feet from residential areas, that the burning will not cause undue visibility or environmental hazard, and that there is no reasonable alternative disposal method available.

Do not breathe the smoke from burning pesticide containers, and do not burn containers that have weed-killers such as 2,4-D or similar herbicides. When these change to a gas, the vapors may damage nearby crops and shrubbery. Pesticides containing chlorates may explode when heated and should not be burned.

Combustible containers that should not be burned can be disposed of in landfills with supplemental permits to handle toxic waste. Commercial applicators with large quantities of **Type I** containers should also dispose of them in supplemental-permitted landfills. Call the Illinois EPA Division of Land Pollution Control to locate the nearest permitted landfill.

**Type II** containers should first be triple-rinsed. Large drums in good condition may then be returned to the pesticide manufacturer, formulator, or drum reconditioner for reuse with the same chemical class of pesticide previously contained, provided that such reuse is legal. Other triple-rinsed metal containers should be punctured to facilitate drainage and prevent reusing for any purpose. Triple-rinsed containers are considered safe to recycle as scrap metal. If no recycling outlet is available, however, they should be hauled to a sanitary landfill for disposal.

Triple-rinsed metal drums that cannot be returned should be crushed and stored in the pesticide storage area until they can be taken to a sanitary landfill. After triple rinsing, carefully break glass containers or cut apart plastic containers and store until you can take them to a landfill.

An empty 55-gallon drum makes a good storage container for smaller empty containers. Be sure to cover the drum tightly with a clamp-type cover and store it in a special section of your pesticide storage area. All triple-rinsed containers may be crushed and disposed of by burial in the field by the pesticide user.

**Type III** noncombustible containers that have been triple-rinsed and punctured to facilitate drainage may be disposed of in a sanitary landfill. You should not burn empty containers that held organic mercury, lead, cadmium, arsenic, or inorganic pesticides. These containers are special because the kind of pesticides they contained are very persistent and hazardous in the environment. Special methods, such as encapsulation in a specially designated landfill, may be necessary for their safe disposal. Encapsulation means to seal the pesticide and "empty" container in a sturdy waterproof container so that the contents cannot possibly get out. **Type III** combustible containers should be crushed and buried in a specially designated landfill.

Federal regulations make it illegal to store or dispose of pesticides by means that are likely to cause adverse effects on human health and the environment. It is illegal to dispose of any pesticide, pesticide container, or pesticide-related waste by open dumping, water dumping, well injection, or open burning (except for small quantities if federal, state, and local regulations are met).

No pesticide or pesticide-related waste that is classified as highly toxic or moderately toxic can be disposed of or stored in such a manner that it may contaminate food, feed, or food and feed packaging materials. The penalty for violation of these storage and disposal regulations is the same as that for violating any other provision of the federal pesticide law.

# CHAPTER FOUR: LABELS AND LABELING

The pesticide label contains all of the information necessary for the correct and safe use of any pesticide. The information and instructions on the label reflect years of testing and the expenditure of millions of dollars to prove that the product is safe and effective when used as directed. If the label is read, understood, and all of the directions are followed, the likelihood of misusing or of having an accident with the pesticide is remote. That is why *the most important time in pest control is the time spent in reading the label.*

## INFORMATION ON THE LABEL

### Trade (Brand) Name

The trade or brand name is the manufacturer's name for the product. There may be many trade names for a pesticide, depending upon the number of companies marketing the product. Even various formulations of the same pesticide produced by the same company may have different names. For example, both Cythion and Malatox are trade names for the insecticide malathion.

### Common and Chemical Names

The common name for a pesticide is a name agreed upon to identify an active ingredient in the product. A pesticide manufactured by more than one company may be sold under several brand names, but it always has the same common name. For example, malathion is a common name for an insecticide. The chemical name indicates the chemical composition of a pesticide. The chemical name for malathion is 0,0-dimethyl dithiophosphate of diethyl mercaptosuccinate.

### Ingredients

Every label must list the amounts of active and inert (inactive) ingredients in the formulation. The chemical that is toxic to the pest is listed as the percent or pounds of active ingredient in the formulation. Inert ingredients (emulsifiers, solvents, carriers, etc.) do not need to be identified except by the percent of the formulation that they constitute.

### Net Contents

The net contents number indicates how much pesticide is in the container. This number may be expressed in gallons, quarts, pints, pounds, or other units.

### Name and Address of Manufacturer

The manufacturer of a pesticide is required to list the name and address of the company on the label so that the applicator will know where to call for information in case of an emergency.

### Registration and Establishment Numbers

You should look for two numbers on a pesticide container: the registration number and the establishment number. The registration number, which indicates that the product has been registered with the U.S. EPA, usually appears on the front label. The establishment number indicates the factory that produced the pesticide. This number may appear either on the label or on the container itself.

The law requires that both the registration and the establishment numbers appear on every pesticide label or container. If an applicator uses a pesticide that has not been registered, he is breaking the law.

### Use Classification

All pesticide labels must contain a statement of the use classification assigned by the EPA at the time of registration. In classifying a pesticide for either general use or restricted use, the EPA considers the toxicity of the pesticide, the way in which the pesticide will be used, and the effect of the pesticide on the environment.

A **general use pesticide** is one that will not harm the applicator or the environment to an unreasonable degree when it is used exactly according to directions. The pesticide label identifies general use with this statement: "General use pesticide — available to the public."

A **restricted use pesticide** is one that could harm the environment or the applicator even when used as directed. The pesticide label identifies restricted use with this statement: "Restricted use pesticide for pur-

chase and use only by certified applicators or by persons under their direct supervision." The restricted use statement must appear at the top of the front panel. The label may limit the use of the product to certain categories of commercial applicators.

Any pesticide classified for general use on certain crops and restricted use on others must be labeled separately and sold as separate products with different registration numbers.

## Directions for Use

Immediately under the heading *Directions for Use* on the label, the manufacturer will again indicate whether the pesticide is for general or restricted use.

The label lists only registered (legal) uses for the pesticide. Remember — it is *illegal* to use any pesticide in a manner inconsistent with the directions on the label. The directions for use also include the following:

(1) The crops, animals, areas, or objects to be treated. (2) The target pest that the pesticide will control. (3) The amount to use (per acre, per 1,000 feet of row, or per gallon of water). (4) The method of application and type of equipment. (5) The frequency and timing of applications necessary to obtain effective results. (6) Specific limitations on reentry to treated areas. (7) Instructions for proper storage and disposal of the pesticide and its container. (8) Limitations or restrictions on use to prevent unreasonable adverse effects on the environment, including required time between applications or before harvest of the crop, crop-rotation restrictions, and warnings against using on certain crops and animals or adjacent to water.

## Precautionary Statements

The pesticide label also contains certain precautionary statements concerning hazards to the applicator, children, domestic animals, wildlife, and the environment.

### *Signal Words*

Labels do not usually give the toxicity of a pesticide as an $LD_{50}$ value for the oral, dermal, and inhalation exposure. The potential danger is indicated, however, by the signal words *Danger-Poison* (with a skull and crossbones) for a highly toxic pesticide, *Warning* for a moderately toxic pesticide, and *Caution* for pesticides with low or slight toxicity. The statement *Keep out of the reach of children* is also required on each pesticide label. Be sure that you understand the meaning of these signal words so that you can take proper safety measures when handling pesticides with various toxicities.

### *Statement of Practical Treatment (First-Aid)*

The labels for all highly toxic pesticides must give instructions for first-aid treatment in case of accidental poisoning. Many of the labels for the less toxic pesticides will also list first-aid treatments. These statements of practical treatment are also helpful to your physician. Be sure to take the container with you if you need to see your physician for treatment of pesticide poisoning.

### *Hazards to the Environment and Humans*

When a hazard exists to bees, fish, or wildlife, the label will give the nature of the hazard and appropriate precautions to avoid accident, injury, or damage to nontarget species or to the environment.

A statement of the human hazard and the route or routes of exposure, together with a list of precautions to avoid accident, injury, or damage, will be on the label.

### *Physical or Chemical Hazards*

Warnings as to whether the pesticide is flammable, explosive, or may create other hazards also appear on the label.

## READING THE LABEL

**Before you buy a pesticide,** read the label to determine:

(1) Whether it is the pesticide you need for the job. Never buy a pesticide simply on the basis of the color of the label or the product name. (2) Whether the pesticide is too hazardous to be used safely under the application conditions.

**Before you mix the pesticide,** read the label to determine:

(1) What protective equipment you should use. (2) What the pesticide can be mixed with (compatibility). (3) How much pesticide to use.

**Before you apply the pesticide,** read the label to determine:

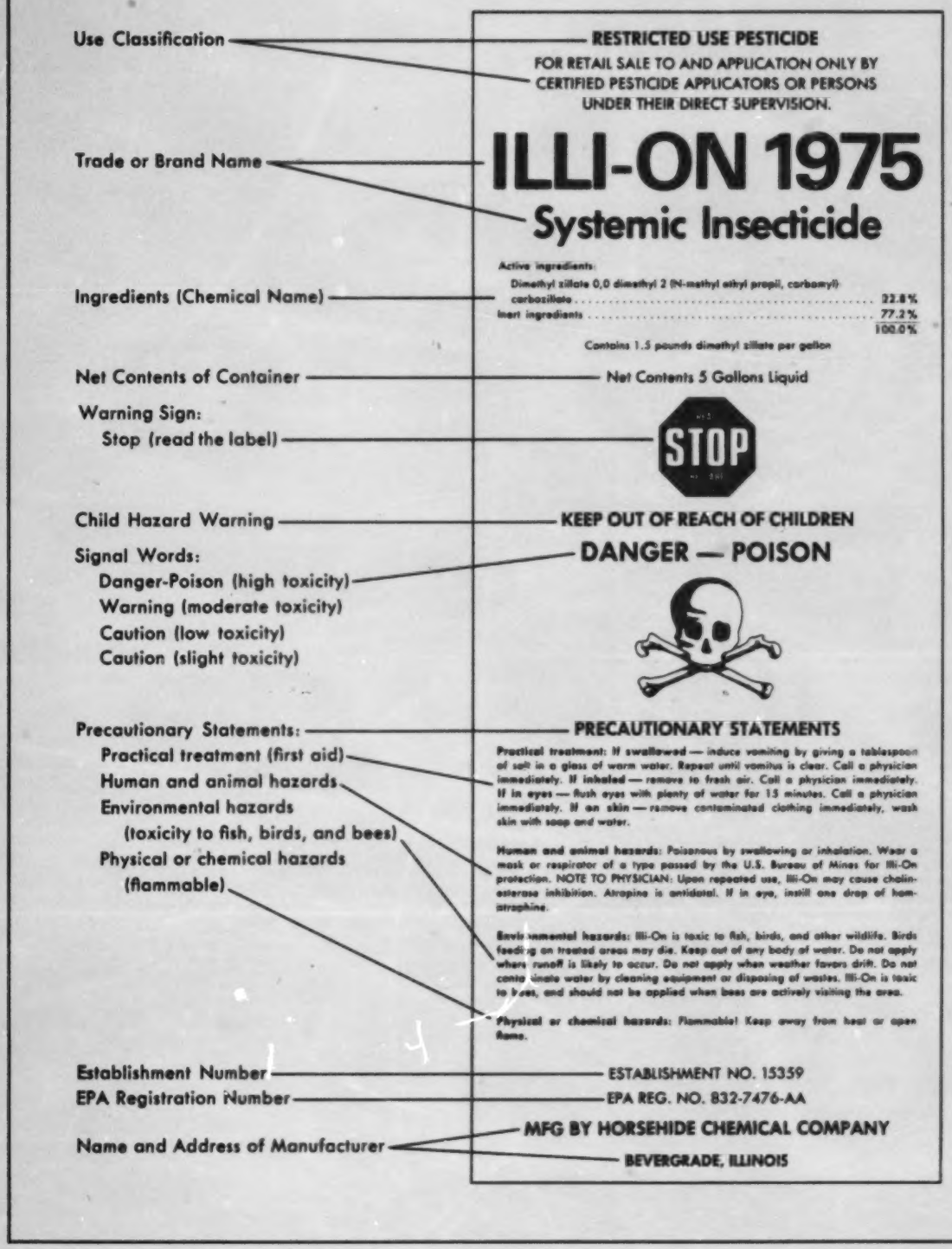
(1) What safety measures you should follow. (2) Where the pesticide can be used (livestock, crops, structures, etc.). (3) When to apply the pesticide (including the waiting period for crops and animals). (4) How to apply the pesticide. (5) Whether there are any restrictions for use of the pesticide.

**Before you store or dispose of the pesticide or pesticide container,** read the label to determine:

(1) Where and how to store the pesticide. (2) How to decontaminate and dispose of the pesticide container. (3) Where to dispose of surplus pesticides.

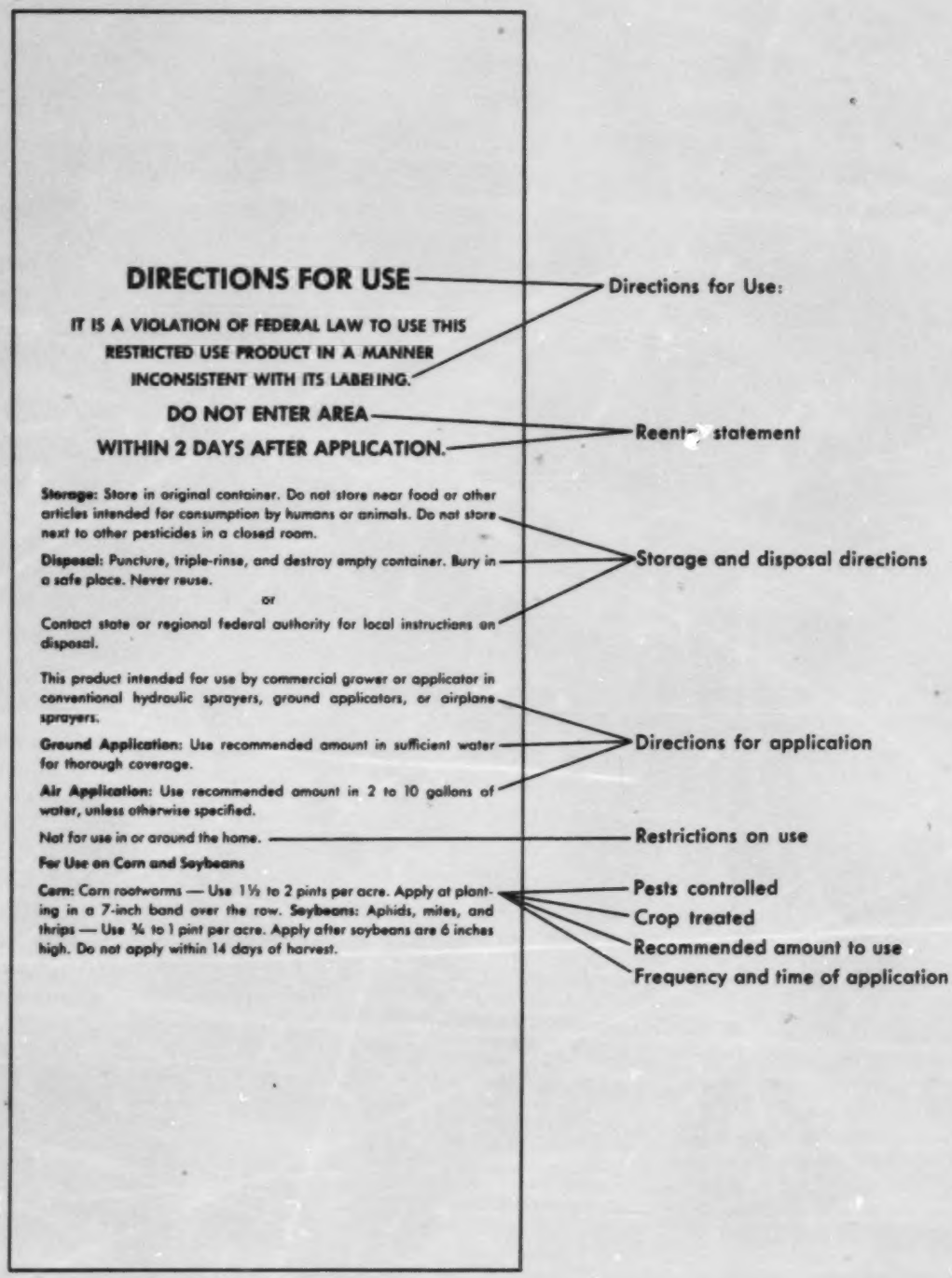
## SAMPLE PESTICIDE LABEL

FRONT


Use Classification
RESTRICTED USE PESTICIDE
FOR RETAIL SALE TO AND APPLICATION ONLY BY CERTIFIED PESTICIDE APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION.
Trade or Brand Name
ILLI-ON 1975
Systemic Insecticide
Ingredients (Chemical Name)
Active ingredients:
Dimethyl zillate 0,0 dimethyl 2 (N-methyl ethyl propil, carbamyl) carboxillate ..... 22.8%
Inert ingredients ..... 77.2%
100.0%
Contains 1.5 pounds dimethyl zillate per gallon
Net Contents of Container
Net Contents 5 Gallons Liquid
Warning Sign:
Stop (read the label)
STOP
Child Hazard Warning
KEEP OUT OF REACH OF CHILDREN
Signal Words:
Danger-Poison (high toxicity)
Warning (moderate toxicity)
Caution (low toxicity)
Caution (slight toxicity)
DANGER — POISON
Precautionary Statements:
PRECAUTIONARY STATEMENTS
Practical treatment (first aid)
Human and animal hazards
Environmental hazards
(toxicity to fish, birds, and bees)
Physical or chemical hazards
(flammable)
Practical treatment: If swallowed — induce vomiting by giving a tablespoon of salt in a glass of warm water. Repeat until vomitus is clear. Call a physician immediately. If inhaled — remove to fresh air. Call a physician immediately. If in eyes — flush eyes with plenty of water for 15 minutes. Call a physician immediately. If on skin — remove contaminated clothing immediately, wash skin with soap and water.
Human and animal hazards: Poisonous by swallowing or inhalation. Wear a mask or respirator of a type passed by the U.S. Bureau of Mines for Illi-On protection. NOTE TO PHYSICIAN: Upon repeated use, Illi-On may cause cholinesterase inhibition. Atropine is antidotal. If in eye, instill one drop of homatrophine.
Environmental hazards: Illi-On is toxic to fish, birds, and other wildlife. Birds feeding on treated areas may die. Keep out of any body of water. Do not apply where runoff is likely to occur. Do not apply when weather favors drift. Do not contaminate water by cleaning equipment or disposing of wastes. Illi-On is toxic to bees, and should not be applied when bees are actively visiting the area.
Physical or chemical hazards: Flammable! Keep away from heat or open flame.
Establishment Number
ESTABLISHMENT NO. 15359
EPA Registration Number
EPA REG. NO. 832-7476-AA
Name and Address of Manufacturer
MFG BY HORSEHIDE CHEMICAL COMPANY
BEVERGRADE, ILLINOIS

## SAMPLE PESTICIDE LABEL

BACK


DIRECTIONS FOR USE
IT IS A VIOLATION OF FEDERAL LAW TO USE THIS RESTRICTED USE PRODUCT IN A MANNER INCONSISTENT WITH ITS LABELING.
DO NOT ENTER AREA
WITHIN 2 DAYS AFTER APPLICATION.
Storage: Store in original container. Do not store near food or other articles intended for consumption by humans or animals. Do not store next to other pesticides in a closed room.
Disposal: Puncture, triple-rinse, and destroy empty container. Bury in a safe place. Never reuse.
or
Contact state or regional federal authority for local instructions on disposal.
This product intended for use by commercial grower or applicator in conventional hydraulic sprayers, ground applicators, or airplane sprayers.
Ground Application: Use recommended amount in sufficient water for thorough coverage.
Air Application: Use recommended amount in 2 to 10 gallons of water, unless otherwise specified.
Not for use in or around the home.
For Use on Corn and Soybeans
Corn: Corn rootworms — Use 1½ to 2 pints per acre. Apply at planting in a 7-inch band over the row. Soybeans: Aphids, mites, and thrips — Use ¾ to 1 pint per acre. Apply after soybeans are 6 inches high. Do not apply within 14 days of harvest.
Directions for Use:
Reentry statement
Storage and disposal directions
Directions for application
Restrictions on use
Pests controlled
Crop treated
Recommended amount to use
Frequency and time of application

# CHAPTER FIVE: APPLICATION EQUIPMENT AND CALIBRATION

Proper application of a pesticide requires the use of the prescribed equipment for the purpose intended. Many types of application equipment are available, including fumigators, granular applicators, and aerial and ground sprayers.

## GROUND SPRAYERS

Ground sprayers ranging from small hand sprayers to large, self-propelled floater units are used more than any other type for pesticide application in Illinois.

### Small-Capacity Sprayers

Small-capacity sprayers are designed for spot treatments, home and garden pest control, small tree and nursery spraying, and for restricted areas unsuitable for larger units. Most hand sprayers use carbon dioxide or compressed air to pressurize the supply tank, forcing the spray liquid through a nozzle. Several types of small power sprayers are available that deliver 1 to 3 gallons per minute at pressures up to 300 psi. Adjustable hand guns are usually used with these units, but spray booms are available on some models. These sprayers are relatively inexpensive, simple to operate, highly maneuverable, and easy to clean and store.

### Low-Pressure General Use Sprayers

General use sprayers are designed for spraying field crops, turf, pastures, fencerows, livestock, etc. They are used to apply a wide range of materials, including herbicides, insecticides, and fertilizers. General use sprayers may be tractor-mounted, pull-type, or self-propelled. Small tank sprayers (50 to 200 gallons) requiring low flow rates usually have roller-type pumps that limit spraying pressure to about 80 psi for continuous spraying. Pressures higher than 80 psi cause excessive pump wear. High-capacity sprayers with large tanks (200 to 1,300 gallons) requiring large flow rates for proper agitation usually have centrifugal pumps. Centrifugal pumps have a long life even with abrasive pesticides, but maximum spraying pressures are limited to 50 to 60 psi.

### High-Pressure Sprayers

High-pressure sprayers are used primarily for spraying fruits, vegetables, and trees for disease and insect control. These sprayers provide the high pressures necessary to produce small drops for complete coverage of the fruit and foliage. They are also used for spraying ornamentals and livestock and to wash equipment.

High-pressure sprayers are similar in design to low-pressure general use sprayers except that they have piston pumps. The pumps deliver up to 50 gallons per minute at pressures up to 800 psi. All components are designed to withstand the high pressures. Field booms are designed for specific crop uses such as tomato, grape, or orchard spraying. Hand guns can be used for large tree or livestock spraying. When fitted with the proper pressure regulators, high-pressure sprayers can be used as general use sprayers at low pressures.

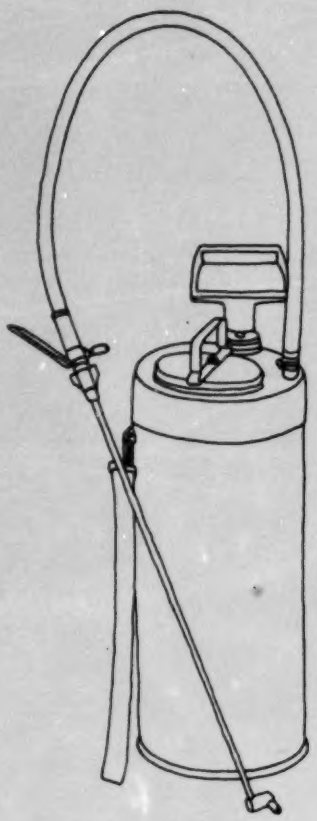
### Air-Blast Sprayers

Air-blast sprayers use a stream of air to carry the pesticide spray to the target. Nozzles deliver the spray into a high-velocity airstream that breaks the droplets into finer particles for thorough coverage. The air is directed into the trees or across a field (peas, tomatoes, beans, etc.).

Special air-blast sprayers that have higher air velocities (120 to 200 MPH) and lower air volume than standard air-blast sprayers are known as "mist blowers." The spray is finer and the application rate is lower than those of the standard air-blast sprayers. They are used on fruits and vegetables, shade tree spraying, space spraying, and mosquito control.

### Use and Maintenance

Select an area for filling, rinsing, and draining your sprayer that will not contaminate any water supply and where people and pets are not likely to be present. Before opening the container, *read the label directions carefully* for recommended protective clothing, special precautions, and proper equipment selection and operation.



Hand Sprayer

Follow the label directions for adding pesticide to the tank. Do not mix more than you plan to use. Apply all of it. Remove all pesticides, especially wettable powders, from the sprayer immediately after spraying.

### *Before Spraying*

Rinse out the entire system and remove and clean nozzles, nozzle screens, and strainers. Make sure that the strainers and nozzle screens are 50-mesh or larger when wettable powders are used. All of the nozzles should be of the same type, size, and fan angle. Nozzle caps should not be cracked or overtightened, especially if they are plastic. Check the lines, valves, seals, and tank after filling with water and during application to be sure that there are no leaks.

Adjust nozzle height and spacing as suggested by the manufacturer on the pesticide label, and as required for the particular crop or pest. In spraying the soil surface, a good check is to spray on asphalt pavement and watch for streaks as the spray dries. Check each nozzle for uniform flow, using water and a jar marked in ounces. Replace any nozzle with a flow 5 percent more or less than the average, as well as any nozzles with heavy or light streaks.

Only water that looks clean enough to drink should be used in a sprayer. A small amount of silt or sand can rapidly wear pumps and other parts of the sprayer system.

Use only the chemicals that the sprayer and pump were designed to use. For example, one application of certain liquid fertilizers will completely ruin copper, brass, ordinary steel, and galvanized surfaces.

### *During Spraying*

Operating a pump dry or with a restricted inlet will damage the pump. Do not operate pumps at speeds or pressures higher than the manufacturer recommends.

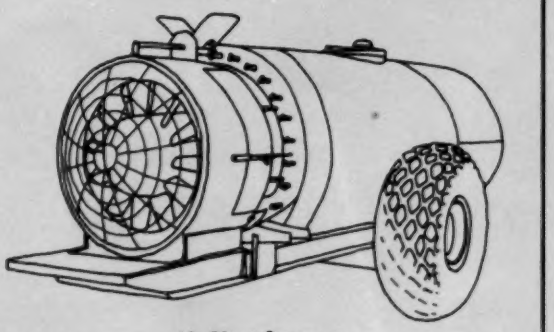
Power-takeoff mounted pumps should be restrained from rotating by chains or torque bars. Blocking the pump with a metal bar can result in misalignment of the pump bearings and shorten the life of the pump. Keep all shields in place.

Do not use speeds too high for ground conditions. Booms bouncing up and down or back and forth can cause application rates to vary by 50 percent. High speeds in rough fields with a full tank can damage the frame of a sprayer or whiplash a boom out of shape.

If nozzles clog or other trouble occurs in the field and the spray material is toxic, shut off the sprayer and move to an unsprayed area before dismounting to work on the sprayer.

Be alert for nozzle clogging, changes in nozzle patterns, and the location of sensitive crops, waterways, people, pets, etc. *The spray must be kept on the target.*

Clean and unclog nozzles with a toothbrush or toothpick, never with a metal object. *Never* try to unclog a nozzle by blowing through it with your mouth.



Air-Blast Sprayer

### After Spraying

Flush the spray system with water after each day's use and at the end of each pesticide use.

If switching to another pesticide where contamination must be prevented, wash out the spray system with detergent and water two or three times and then flush with water. Phenoxy herbicides such as 2,4-D are difficult to remove. After their use, either follow the special cleaning procedures noted on the pesticide label or do not use the sprayer for any other product.

Keep the tank clean inside and out. Tighten or repair all leaky tank seals or fittings. Make sure that sight gages can be read.

Inspect all strainers, screens, and nozzle tips after each day of spraying. If cleaning is necessary, remove the accumulation by soaking and brushing. Never use metal for cleaning — it may damage or enlarge the openings.

Check pressure gages frequently against an accurate gage to prevent overpressure. Glass faces must be clean and intact.

Do not allow the hoses to become kinked or abraded. Rinse the hoses often to prolong their life, and replace them at the first sign of deterioration.

### Cleaning and Storage

Clean the sprayer thoroughly after each use or when chemicals are changed. Many chemicals cause rapid corrosion of the metal, and should be removed immediately after use. Sometimes a residue will react with succeeding chemicals, causing a loss of effectiveness.

To clean a sprayer, mix about 2 pounds of detergent per 40 gallons of water in the tank. Circulate this mixture through the bypass or agitator nozzles for 30 minutes and then drain, allowing some solution to pass through the boom and nozzles.

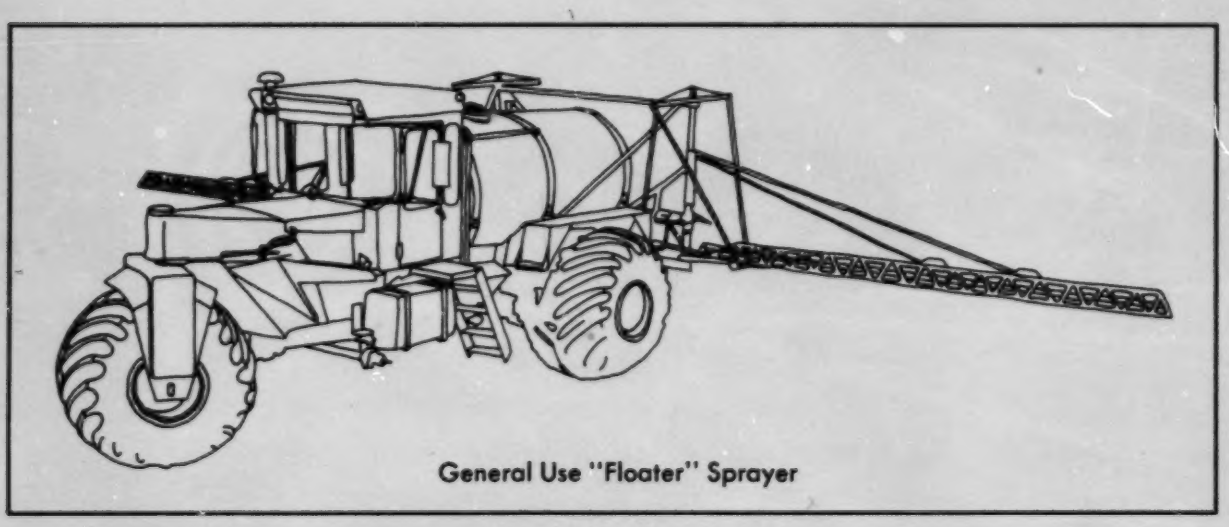
If phenoxy herbicides such as 2,4-D, 2,4,5-T, or brush-killer were used in the sprayer, rinse with an ammonia or charcoal solution. To make an ammonia rinse, fill the tank one-third to one-half full and add 2 quarts of household ammonia per 25 gallons of water. Circulate the solution and allow a small amount to flow through the nozzles. Allow the remaining solution to stand overnight to neutralize any herbicide remaining in the equipment, and then pump the solution through the nozzles. After rinsing with detergent or ammonia, flush thoroughly with clean water.

When storing your sprayer, add 1 to 5 gallons of lightweight oil (depending upon the size of the tank) before the final flushing. As the water is pumped from the sprayer, the oil will leave a protective coating on the inside of the tank, pump, and plumbing.

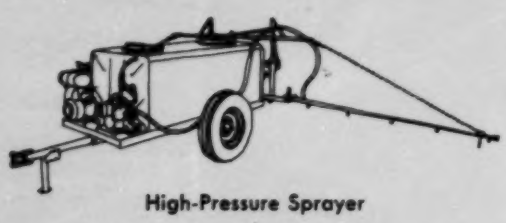
To prevent corrosion, remove nozzle tips and screens and store them in a can of light oil such as diesel fuel or kerosene. Close the nozzle openings with masking tape to keep dirt from entering.

Drain the pump thoroughly to prevent freezing. Add a small amount of oil and rotate the pump four or five revolutions by hand to completely coat interior surfaces. Engine-equipped sprayers require additional servicing. Follow the directions in the owner's manual.

After thorough cleaning and draining, store the sprayer in a reasonably clean and dry building. If you store the sprayer outside, remove the hoses, wipe them clean of oil, and store them inside where they will not become damaged. With trailer sprayers, you may wish to put blocks under the frame or axle and reduce tire pressure during storage.



General Use "Floater" Sprayer



High-Pressure Sprayer

## Nozzle Spray Patterns

It is impossible to overstress the importance of proper nozzle selection and use. Nozzles control the volume of pesticide applied, the uniformity of application, the thoroughness with which the surface is covered, and the amount of drift. Although nozzles have been developed for practically every kind of spray application, they all produce one of four basic spray patterns. These patterns are discussed below.

### *Cone Patterns*

Cone nozzles produce a solid or a hollow spray pattern. Fan angles of 50 to 110 degrees are produced by the use of a core or whirl plate with an orifice disc. The solid cone spray pattern is frequently obtained by using a disc and core with tangential slots and an orifice in the center of the core.

**Whirl chamber nozzles** have a whirl chamber above a conical outlet. These nozzles produce a hollow-cone pattern with fan angles up to 130 degrees. They produce coarse droplets when operated at low pressures of 5 to 20 psi.

**Hollow-cone nozzles** are used primarily when penetration of the spray surface is essential for effective insect and disease control, and when drift is not a major concern. These nozzles produce small drops that penetrate under leaves better than the droplets produced by flat-fan nozzle types.

Any nozzle producing a cone pattern, including the whirl-chamber type, will not provide uniform distribution for broadcast applications unless the nozzles are tilted forward or backward on the boom at an angle of 15 to 30 degrees from the vertical.

### *Flat-Fan Patterns*

Three nozzle types produce a flat-fan spray pattern. The **regular flat-fan nozzle,** which produces a narrow oval pattern, is available in fan angles of 60 to 110 degrees. Since the outer edges of the pattern have lower volumes, adjacent patterns must be overlapped 30 to 50 percent to obtain uniform coverage. Regular flat-fan nozzles are usually spaced on 20-inch centers with a boom height of 17 to 23 inches.

At low pressures, regular flat-fan nozzles produce medium to coarse droplets that are not as susceptible to drift as fine droplets. Drifting can occur, however, and herbicides such as 2,4-D and Banvel can cause damage to sensitive crops at great distances. These nozzles are recommended for applying herbicides and some insecticides where penetration and complete coverage of the foliage are not necessary. When applying herbicides with regular flat-fan nozzles, the pressure should be between 15 and 30 psi, and *never* over 40 psi.

The **even flat-fan nozzle** is designed to apply an even coverage across the entire width of the spray pattern. In other respects, it is quite similar to the regular flat-fan nozzle. The even flat-fan nozzle should be used only for band applications of pesticides.

The **flooding flat-fan nozzle** is recommended for applying herbicides and mixtures of herbicides and fertilizers. Boom-mounted nozzles on 40- to 144-inch centers allow you to spray wide swaths with only a few nozzles. For applying herbicides, the nozzle spacing should be 60 inches or less. These nozzles are best for reducing drift, and can be used at pressures as low as 10 psi. Pressure changes affect the width of the spray pattern more with flooding flat-fan nozzles than with regular flat-fan nozzles. You will obtain best distribution with the nozzles rotated so that they spray backward from the direction of travel with double coverage.

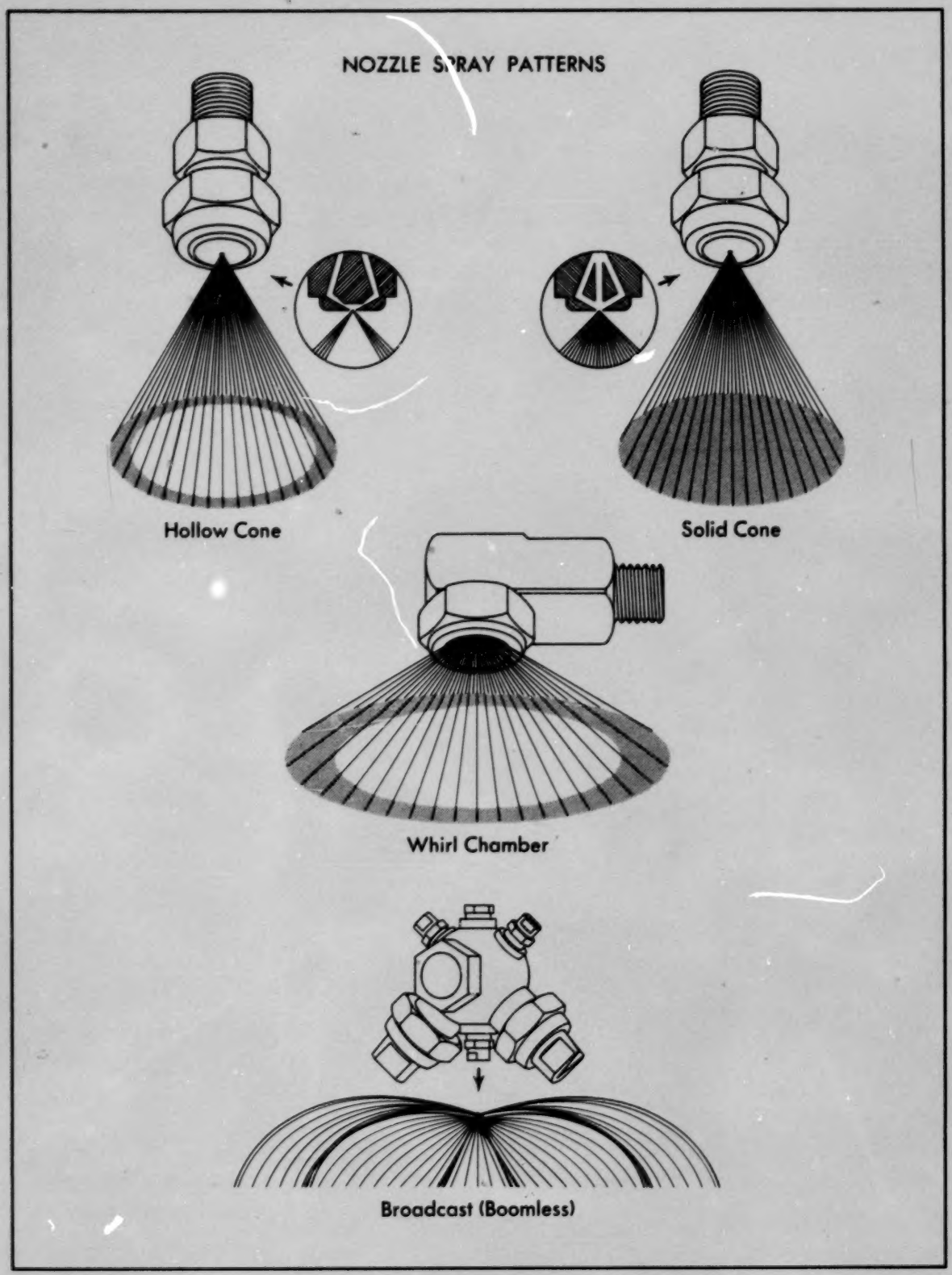
### *Broadcast Patterns*

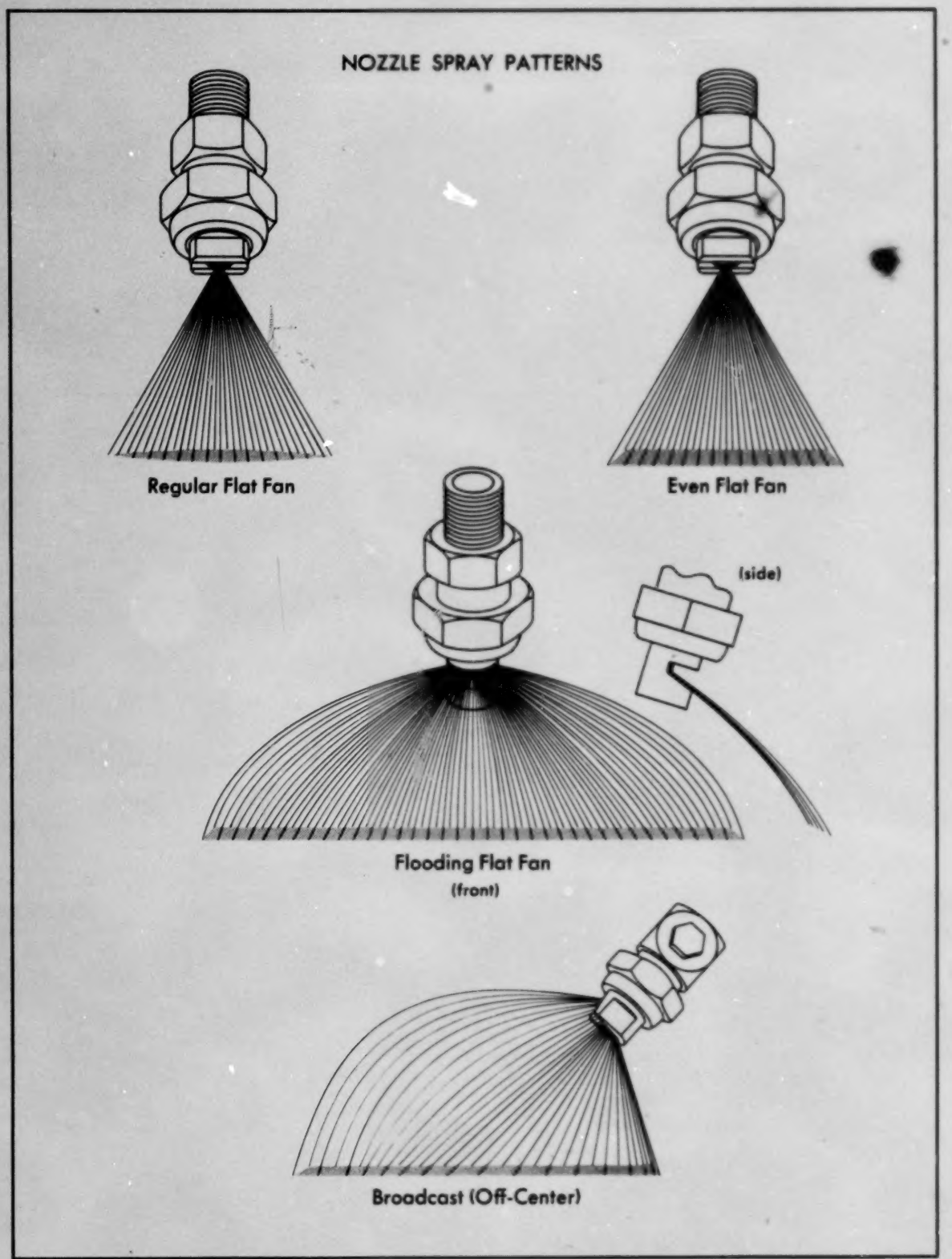
Broadcast nozzles are used to spray swaths up to 30 feet or more. The spray is more susceptible to drift than that from nozzles mounted on a spray boom, and the distribution across the swath is not as uniform as with the other nozzle types. Broadcast nozzles produce small droplets immediately under the nozzle, but extremely large droplets are deposited at the outer edge of the swath.

Broadcast nozzles are used for boomless sprayers, to extend the effective width on the end of the boom, or when thorough coverage of the surface is not necessary. They are not recommended for field crops, but are suggested for spraying pastures, fencerows, and roadsides where obstructions make a boom undesirable.

### *Solid Stream Patterns*

A compact jet (solid stream) is often used in handguns to spray a distant target, to apply a narrow band or barrier, or to inject pesticides into the soil.


NOZZLE SPRAY PATTERNS
Hollow Cone
Solid Cone
Whirl Chamber
Broadcast (Boomless)


NOZZLE SPRAY PATTERNS
Regular Flat Fan
Even Flat Fan
(side)
Flooding Flat Fan
(front)
Broadcast (Off-Center)

## Nozzle Selection

More than one nozzle type or pattern may be used for many spraying jobs. In general, the regular flat-fan, flooding flat-fan, and whirl chamber nozzles are preferred for weed control. When herbicide drift control is most essential, the flooding nozzles and whirl chamber nozzles provide larger drops and adequate patterns at lower pressures (5 to 15 psi). They also do not clog as readily as regular flat-fan nozzles.

For chewing insects, flat-fan or hollow-cone nozzles can be used on field crops. To obtain adequate coverage in controlling diseases and other insects, use hollow-cone nozzles operating at pressures of 40 to 100 psi.

Nozzles are manufactured in various materials, with brass the most common. Brass is relatively inexpensive, but it is not resistant to abrasion. Stainless steel is noncorrosive and much more resistant to abrasion than brass, especially if it is hardened. Nylon and other plastics are resistant to corrosion and have fair abrasion resistance, but are subject to swelling by some liquids.

Aluminum is quite resistant to some corrosive materials but easily corroded by others, such as some nitrogen fertilizers. Tungsten carbide is highly resistant to abrasion and corrosion, but is available only in disc-type hollow-cone nozzles that are expensive. For limited use, brass tips are probably best. For more extensive use, especially of corrosive or abrasive pesticides, other materials should be considered.

## Calibration: General Use Sprayers

The performance of any agricultural chemical depends upon the proper application of the correct amount. Most performance complaints about pesticides are directly related to errors in dosage or improper application. An applicator must be sure that his equipment is uniformly applying the specified amount of material over a given area.

The volume of spray applied depends upon three variables: nozzle flow rate, ground speed of the sprayer, and sprayed width per nozzle.

Nozzle flow rate varies with the orifice size of the nozzle, the nature of the fluid, and the pressure on the fluid. Flow rate is usually proportional to the square root of the pressure at the orifice. Increasing the ground speed of the sprayer decreases the spray volume. The ground speed is the easiest variable to change for minor corrections in application. Increasing the spray width per nozzle (nozzle spacing) decreases the spray volume.

### *Equipment Needed*

You will need calibrated containers of the proper size (1 pint or 1 quart for low application volumes per acre; 1 gallon for high application volumes per acre), a 100-foot tape, a watch with a sweep-second hand, stakes to mark distances, and an accurate pressure gage on the sprayer.

### *Nozzle Tip Selection*

**Step 1.** Determine the sprayer application volume in gallons per acre (GPA) from the pesticide label or printed recommendations. The application volume is the gallons of carrier (water, fertilizer, etc.), plus the amount of chemical applied per treated area.

**Step 2.** Select an appropriate ground speed in miles per hour (MPH) according to existing field conditions. The actual speed may be measured according to Step 1 in the *Calibration Procedure* section (page 33).

**Step 3.** Determine the spray width per nozzle (W) in inches.

For boom spraying, W = the nozzle spacing.

For band spraying, W = the band width.

For row-crop applications, such as spraying from drop pipes or directed spraying,

$$W = \frac{\text{row spacing (or band width)}}{\text{number of nozzles per row (or band)}}.$$

**Step 4.** Determine the output required for each nozzle by using a nozzle manufacturer's catalog or Equation 1 below.

$$\text{(Equation 1)} \quad GPM = \frac{GPA \times MPH \times W}{5{,}940^*}$$

GPM = gallons per minute of output required from each nozzle.

GPA = gallons per acre from Step 1.

MPH = miles per hour from Step 2.

W = inches sprayed per nozzle from Step 3.

* Using 6,000 instead of 5,940 makes the calculation easier, and results in an error of only 1 percent.

**Step 5.** Select a nozzle that will give the output determined in Step 4 when operating within the recommended pressure range. At this point, you may decide to select another operating speed in order to use nozzles that you already have on hand. If so, return to Step 4 and recalculate the required output for the new speed.

### *Precalibration Check*

Install the selected nozzle tips, partially fill the sprayer tank with water, and operate the sprayer at a pressure within the recommended pressure range. Place a container, such as a quart jar, under each nozzle to determine if all jars fill in about the same time. Replace any nozzle with an output of 5 percent more or less than the average of all the nozzles, or with an obviously different fan angle or a nonuniform appearance in spray pattern.

### Calibration Procedure

The following method of calibration can be used for boom, band, directed, and row-crop spraying. Once the method is learned, frequent checks of application rates can be made quickly and easily.

**Step 1.** Lay out a known distance in the field to be sprayed, or in a field with similar soil conditions. A suggested distance is 176 feet for speeds up to 8 MPH. To obtain more accurate settings for speeds above 8 MPH, stake out 352 feet. At the engine throttle setting and gear you plan to use during spraying with a loaded sprayer, determine the travel time between stakes in each direction. Average these speeds, and use Equation 2 or the table below to determine the travel speed.

$$\text{(Equation 2)}\quad \text{Speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

**Example:** If it takes 24 seconds to travel 176 feet, the ground speed $= \frac{176 \times 60}{24 \times 88} = \frac{120}{24} = 5$ MPH.

| Distance (feet) | Speed (MPH) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 3.5 | 4 | 4.5 | 5 | 6 | 8 | 10 | 12 | 15 |
| | (seconds) | | | | | | | | | |
| 88 | 20 | 17 | 15 | .. | .. | .. | .. | .. | .. | .. |
| 176 | .. | .. | 30 | 27 | 24 | 20 | 15 | .. | .. | .. |
| 352 | .. | .. | .. | .. | .. | .. | 30 | 24 | 20 | 16 |

Once you have decided upon a particular speed, record the throttle setting and drive gear used.

**Step 2.** Using Equation 1 or a nozzle manufacturer's catalog, determine the output needed per nozzle in gallons per minute (GPM). Convert this figure to ounces per minute (OPM) by using Equation 3.

$$\text{(Equation 3)}\quad \text{OPM} = \text{GPM} \times 128$$

**Example:** To broadcast 20 gallons per acre at a speed of 5 miles per hour with a nozzle spacing on the boom of 20 inches, you need a nozzle flow rate of 0.337 gallons per minute, or 43 ounces per minute.

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W (nozzle spacing, inches)}}{5{,}940}$$

$$\text{GPM} = \frac{20 \times 5 \times 20}{5{,}940} = 0.337$$

$$\text{OPM} = \text{GPM} \times 128 = 0.337 \times 128 = 43$$

The table below may be used in place of the formulas. To use the table, locate the gallons per acre of spray volume selected. Follow across to the column marked with the ground speed determined in Step 1. The factor at the intersection of these two columns is ounces per minute per inch of spray width. To determine the output required per nozzle, multiply the factor in the table times the spray width per nozzle.

**Example:** Speed = 6 MPH; volume = 15 GPA; nozzle spacing (W) = 30 inches.

From the table, the factor for OPM is 1.94. The nozzle output required is $1.94 \times 30 = 58.2$ OPM.

**Step 3.** Measure the output in ounces per minute by collecting the water from a representative nozzle. Adjust the pressure until the amount collected is the same as that determined in Step 2. Check another nozzle to determine if its output is also within 5 percent of the desired output. If it is impossible to obtain the desired output within the recommended range of operating pressures, select larger or smaller tips or a new operating speed and recalibrate. Spray nozzles must be operated within the recommended pressure range.

**Step 4.** Determine the amount of pesticide needed for each tank or for the acreage to be sprayed, and add this amount to a partially filled tank of water. Then add water to the desired level.

**Step 5.** Operate the sprayer in the field at the ground speed determined from Step 1 and under the pressure determined from Step 3. After spraying a known number of acres, check the liquid level in the tank to verify that the proper application volume is being dispersed.

**Step 6.** From time to time, check the nozzle flow rate. Adjust the pressure to compensate for small changes in nozzle output resulting from nozzle wear or variations in other spraying components. When the output has changed 10 percent or more from that of a new nozzle, or when the pattern has become uneven, replace the nozzle tips and recalibrate.

| Volume (GPA) | Speed (MPH) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 3.5 | 4 | 4.5 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 |
| | (OPM per 1 inch of spray width) | | | | | | | | | | | |
| 5 | .32 | .38 | .43 | .48 | .54 | .65 | .75 | .86 | .97 | 1.08 | 1.29 | 1.62 |
| 10 | .65 | .76 | .86 | .97 | 1.08 | 1.29 | 1.51 | 1.72 | 1.94 | 2.15 | 2.59 | 3.23 |
| 15 | .97 | 1.13 | 1.29 | 1.45 | 1.62 | 1.94 | 2.26 | 2.59 | 2.91 | 3.23 | 3.88 | 4.85 |
| 20 | 1.29 | 1.51 | 1.72 | 1.94 | 2.15 | 2.59 | 3.02 | 3.45 | 3.87 | 4.31 | 5.17 | 6.46 |
| 30 | 1.94 | 2.27 | 2.59 | 2.91 | 3.23 | 3.88 | 4.52 | 5.17 | 5.82 | 6.46 | 7.76 | 9.70 |
| 40 | 2.58 | 3.02 | 3.44 | 3.88 | 4.30 | 5.18 | 6.04 | 6.90 | 7.74 | 8.62 | 10.34 | 12.92 |

## DUSTERS AND GRANULAR APPLICATORS

### Hand Dusters

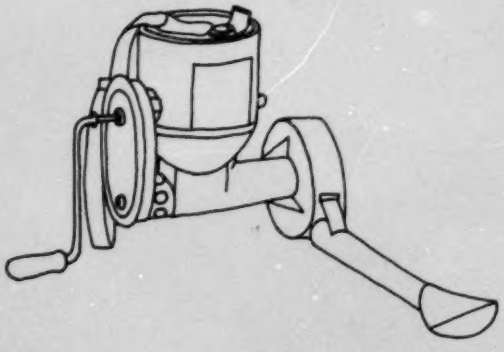
Like hand sprayers, hand dusters are used primarily for small areas. They may consist of simply a squeeze tube or shaker, a sliding tube, or a fan powered by a hand crank. Hand dusters have an advantage over sprayers because the pesticide has been prediluted and is ready to apply on small areas or for spot treatment.

### Power Dusters

Ground-rig power dusters utilize a powered fan or blower to propel the dust to the target. They range from knapsack or backpack types to tractor-mounted or pulled. Power dusters are simply constructed, easy to maintain, and low in application cost. Because of the drift hazard, however, the use of dust for controlling pests has decreased in recent years.

### Granular Applicators

Granular applicators range from crank-operated, spinning disc, knapsack types for broadcast coverage, to those applying bands over the row in row crops, to powered applicators covering 20-foot widths or more in front of incorporating tools. Granules, like dusts, are prediluted so that there is no need for mixing.



Hand Duster

### Use and Maintenance

Since both dusters and granular applicators are speed-sensitive, try to maintain uniform speed. If you travel too fast for conditions, the applicators will bounce, resulting in a widely varying application rate. Stay out of any drift cloud that may form. Wind can greatly affect the distribution from granular applicators, and makes the application of dusts virtually impossible. Finish the day or job with each box almost empty. Clean the equipment at the end of the job as directed by the operator's manual. When banding granules, be sure that the proper band width is maintained. Small height changes because of varying soil conditions can result in changes in band width.

### Calibration: Broadcast Granular Applicators and Dusters

**Step 1.** Read the pesticide label to determine the application rate, and set the machine as recommended by the operator's manual for a starting setting. Set gate openings from one direction only, such as from "closed" to "open," to eliminate variation in setting.

**Step 2.** Fill the tank or hopper to an easily determined level designated by a mark drawn across the tank with a rule and marking pen.

**Step 3.** Apply to a known acreage in the area to be treated.

**Step 4.** Refill hopper or refill to mark as appropriate, weighing container before and after filling to determine the amount used.

**Step 5.** Determine the application rate by using Equations 4 and 5.

(Equation 4) Acres covered =

$$\frac{\text{distance traveled (feet)} \times \text{swath width (feet)}}{\text{43,560 (square feet per acre)}}$$

(Equation 5) Application rate (pounds per acre) =

$$\frac{\text{amount used (pounds)}}{\text{acres covered}}$$

**Step 6.** If the application rate determined in Step 5 is not the desired rate, readjust the applicator setting and repeat Steps 2 to 5 until the desired rate is obtained.

**Example:** After determining that 60 pounds per acre is the desired rate, set the applicator and fill the hopper. Make two rounds in a field with one-half mile rows (2,640 feet), using a swath width of 30 feet. After refilling the hopper, you discover that the amount used was 450 pounds.

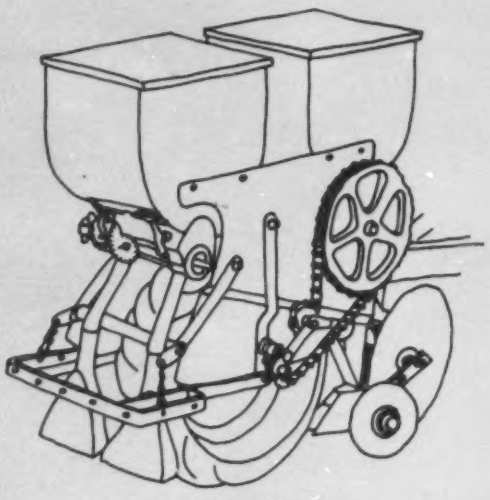
Acres covered =

$$\frac{4 \text{ swaths} \times 30 \text{ feet} \times 2{,}640 \text{ feet}}{43{,}560} = \frac{316{,}800}{43{,}560} = 7.28 \text{ acres}$$

Application rate =

$$\frac{450 \text{ pounds used}}{7.28 \text{ acres covered}} = 61.8 \text{ pounds per acre}$$

If the rate becomes any higher as application continues, decrease the setting accordingly.



Band Granular Applicator

### Calibration: Band Granular Applicators

**Step 1.** Set each individual applicator to apply the desired amount per acre, as suggested in the equipment operator's manual.

**Step 2.** Fill hoppers at least one-half full, turn on the applicators, and run them until they all begin feeding.

**Step 3.** Disconnect the feed tubes and attach a container under each tube for each band.

**Step 4.** Travel a measured distance (at least ⅛ mile) at the speed you wish to apply in the field.

**Step 5.** Weigh and record the amount recovered for each band separately. Use an accurate scale such as a postal scale.

**Step 6.** Calculate the application rate for each unit, using Equations 4 and 5 where the band width (in feet) is the swath width. This is the broadcast rate per acre, and the rate that the pest is subjected to in the banded area. The amount used per crop acre will be reduced by the ratio of band width to row width. For some pesticides, such as insecticides, the recommended rate is in pounds per crop acre. Use row spacing (in feet) for swath width in Equation 4, and your answer will be in pounds per crop acre. If the recommendation is in pounds per 1,000 feet of row, then pounds

$$\text{per 1,000 feet of row} = \frac{\text{pounds collected} \times 1{,}000 \text{ feet}}{\text{distance traveled (feet)}}.$$

**Step 7.** If the rate on any unit is not within 5 percent of that recommended, adjust the unit accordingly and repeat Steps 3 to 6 until the rate is within 5 percent.

**Step 8.** Use the method described under *Calibration: Broadcast Granular Applicators and Dusters* during the first part of application to check rate. Adjust settings accordingly. Granular formulations may differ in density, granule size, carrier used, etc. Be sure that you calibrate for each different formulation, and be alert to changes in application rate. A good practice is to mark off the hoppers in a certain measure such as quarts, and check the amount used by each unit at each filling against the acreage covered.

## FUMIGATORS AND INJECTORS

Equipment is of two types — that needed to handle low-volatility fumigants and that needed to handle the high-volatility fumigants that are kept liquid only by storage in pressure vessels. The low-volatile fumigators are gravity flow or pump fed, while the high-volatile fumigators generally use a compressed gas to force the fumigant into the soil or space being fumigated. Some fumigants are sufficiently safe so that covering with plastic or other seal is unnecessary. But most fumigants work best and more safely if seals are used.

### Use and Maintenance

All units, especially the pressurized ones, should be kept in good repair. Make sure that there are no leaks and that hoses and fittings are replaced as soon as they show signs of deterioration. Lines and fittings should not be located near the operator. All lines should be emptied except when actually applying fumigants. Carefully observe all precautions on the fumigant label. To avoid cross-contamination and corrosion, properly flush the units according to the directions on the label.

### Calibration

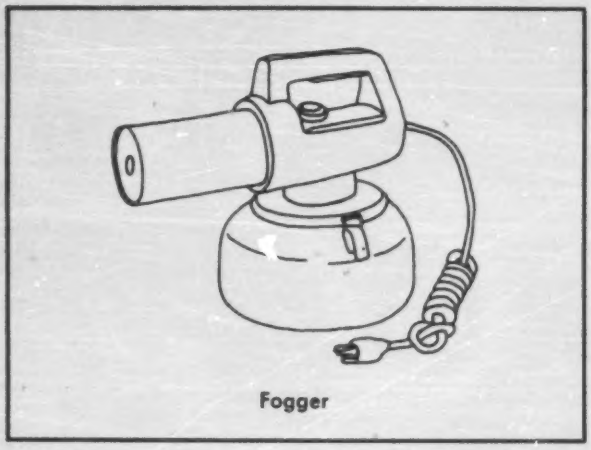
The calibration of nonpressure fumigators is the same as that described under *Calibration Procedure* (page 33). Since the fumigant in a pressure fumigator vaporizes when released from pressure and is usually toxic, it is not practicable to catch it in a calibrated container. You can usually come close to the correct rate for a pressure fumigator by using manuals and label information to select an operating pressure and outlet orifice size that give a particular flow rate. This initial setting, along with outlet spacing and travel speed, can be varied to give the desired application rate.

By starting with a known amount of fumigant and checking the amount used on a known area, you can check the application rate by using Equation 5. Minor changes in speed and operating pressure can be made to obtain the correct rate.

## AEROSOL GENERATORS AND FOGGERS

Aerosols are droplets that are so small that they literally float in the air. These minute droplets penetrate into hard-to-reach areas such as heavy vegetation and recesses in buildings. Unfortunately, this characteristic makes them extremely susceptible to drift. For this reason, only a few pesticides are suitable for use.

Aerosols are generated by air atomizers or pneumatic nozzles, spinning discs, small nozzles at high pressure, and aerosol spray cans. Fogs are usually generated by thermal generators using heated surfaces. Fog particles are so small that they settle out even less than aerosols. Both aerosols and fogs are widely used as space sprays. They give good temporary control, since residual action is minimal.



Fogger

### Use and Maintenance

The same precautions listed for sprayers apply to aerosol generators and foggers. In addition, there are other precautions you must observe. Aerosol generators and foggers produce a spray cloud that is extremely mobile. Make sure that the pesticides used are cleared for application with these machines. Be sure of the weather conditions during spraying, as well as for a period after spraying. *The pesticide must be kept on target.* Whether applications are made inside or outside, the operator, other humans, pets, etc. must be kept out of the spray cloud or be properly protected.

## AERIAL SPRAYERS

Aerial applications are made with both fixed-wing and rotary-wing aircraft. Because of the many excellent agricultural aircraft and spray systems commercially available, it is usually impractical to build your own system.

### Use and Maintenance

Most of the information given on ground-sprayer use is also applicable to aerial spray systems. The following points must also be considered. Tanks should be corrosion-resistant, easy to clean and maintain, and well sealed and plumbed so that they can be filled and emptied by closed systems. Provide emergency dumping. Venting should permit free flow during dumping.

Generally, you should use hydraulically or mechanically driven centrifugal pumps that provide sufficient flow at 45 to 50 psi for the boom at maximum output, plus 10 percent of tank capacity for hydraulic agitation, and 10 percent reserve. Wind-driven pumps are more simply constructed and less expensive than hydraulically driven pumps, but they are less efficient and do not permit calibration on the ground.

Booms on fixed-wing aircraft should be no more than three-fourths of the wingspan to keep spray out of wing-tip vortices. They should also be well supported and have nozzles all the way to the boom end, or a return line to relieve air pockets in the boom and to aid rapid cutoff.

Nozzles should be closer together near the end of the boom, with a 3- or 4-foot gap on the left side of the fuselage and a cluster of three or four nozzles on the right side of the fuselage to compensate for the effect of the propeller slipstream.

Means should be provided for pointing nozzles from forward at 45 degrees for maximum breakup of the spray to straight back for minimum breakup. If rotary screens or discs are used instead of nozzles, they must also be spaced to account for the effects of slipstream and wing-tip vortices. Nozzle or boom check valves must be used to prevent drip after boom cutoff. Since these valves are rendered inoperative by any sediment between the valve and its seat, a good filtration system is important.

Droplet size is affected by nozzle orientation in the airstream, with the finest drops occurring at the 45-degree forward orientation. Hollow-cone nozzles with the core (whirl plate) removed to produce a solid stream are often used to produce coarse sprays that are less subject to drift.

Nozzle or boom-check valves or a suction-return system must be used to provide rapid cutoff at field ends, and to prevent leaking during transport to the field. Foam nozzles, broadcast nozzles, special low-pressure solid-stream nozzles closely spaced behind an air foil, and other special units are all available when drift prevention is of primary importance.

Ultralow volume systems require special pumps, much smaller lines and fittings, small-capacity nozzles or other dispensers, etc. Remember — these systems permit tre-

mendous rates in acres per hour, but only a few pesticides are labeled for ultralow volume applications.

On rotary wing aircraft, the boom can extend beyond the rotor. The boom should be well forward so that the nozzles can be seen and more conventional nozzle spacing can be used.

The aerial applicator should be provided with filtered air. The aircraft and its spray system should be regularly cleaned and checked for corrosion or other deterioration. No leaks of spray material should be tolerated. All check valves need frequent inspection, and weak springs, worn diaphragms, or scarred seats should be quickly replaced. Nozzles should be checked frequently *on the ground* to see that they still provide good patterns and are not worn (more than 10 percent increase in output because of wear is undesirable). If wear becomes a problem, use hardened stainless steel or carbide tips.

Keep the spray system clean and use clear water. Don't allow strainers to clog. A trained ground crew should load the aircraft, not the pilot. The engine should be shut off during loading.

Prior to application, the pilot and the flagmen should check the area to be treated and the surrounding area to make sure that no humans, animals, or crops will be injured by direct application or drift. The pilot should also avoid flying in the spray cloud as much as possible. Applications should be made crosswind, working gradually upwind to protect both the pilot and the flagmen. The pilot should not spray over the flagmen, roads, waterways, etc., but only in the field to be treated.

The ground crew should be sure that the tank and system are tightly sealed. Any material on the airplane should be immediately washed off. The flagmen and pilot should be aware of which pesticide goes on a particular field, be alert for mistakes, and have a means of communicating with one another.

The pilot should be aware of the drift hazards with the spray system he is using, at the altitude he is flying, and the pesticide he is applying. He should be prepared to stop spraying if rising winds, shifting winds, or other changing conditions create a drift hazard.

Aerial sprays are much more subject to drift than ground sprays. When drift control is essential, you can help attain it by proper nozzle selection, orienting nozzles backward, increasing the application rate, flying slower and perhaps lower, using drift-control adjuvants, etc. If drift in a certain direction is hazardous, wait until the wind is from that direction before making the application.

*Remember — mistakes can put you out of business or underground.*

## Calibration

The first step in calibration is to select the nozzles or other dispensing devices to apply the application volume you select from the label recommendations.

### *Nozzle Selection*

**Step 1.** To select nozzles, you must know the ground speed you wish to fly and the approximate swath. You can then use Equation 6 or the table below to determine the number of acres covered per minute.

(Equation 6) Acres per minute =

$$\frac{\text{speed (MPH)} \times \text{swath (feet)}}{495}$$

| Speed (MPH) | Swath width (feet) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| | (Acres per minute) | | | | | | |
| 25 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 |
| 30 | 2.4 | 3.0 | 3.6 | 4.2 | 4.9 | 5.5 | 6.1 |
| 35 | 2.8 | 3.5 | 4.2 | 4.9 | 5.6 | 6.3 | 7.0 |
| 40 | 3.2 | 4.0 | 4.8 | 5.6 | 6.5 | 7.3 | 8.1 |
| 45 | 3.6 | 4.5 | 5.5 | 6.4 | 7.3 | 8.2 | 9.1 |
| 50 | 4.0 | 5.0 | 6.1 | 7.1 | 8.1 | 9.1 | 10.1 |
| 55 | 4.4 | 5.6 | 6.6 | 7.8 | 8.9 | 10.0 | 11.1 |
| 60 | 4.8 | 6.1 | 7.2 | 8.5 | 9.7 | 10.9 | 12.1 |
| 65 | 5.2 | 6.6 | 7.8 | 9.2 | 10.5 | 11.8 | 13.1 |
| 70 | 5.6 | 7.1 | 8.5 | 9.9 | 11.3 | 12.7 | 14.1 |
| 75 | 6.1 | 7.6 | 9.1 | 10.6 | 12.1 | 13.6 | 15.1 |
| 80 | 6.5 | 8.1 | 9.7 | 11.3 | 12.9 | 14.5 | 16.1 |
| 85 | 6.9 | 8.6 | 10.3 | 12.0 | 13.7 | 15.5 | 17.1 |
| 90 | 7.3 | 9.1 | 10.9 | 12.7 | 14.5 | 16.4 | 18.2 |
| 95 | 7.7 | 9.6 | 11.5 | 13.4 | 15.4 | 17.3 | 19.2 |
| 100 | 8.1 | 10.1 | 12.1 | 14.1 | 16.1 | 18.2 | 20.2 |
| 110 | 8.9 | 11.2 | 13.3 | 15.5 | 17.8 | 20.0 | 22.2 |
| 120 | 9.7 | 12.1 | 14.5 | 17.0 | 19.4 | 21.8 | 24.2 |

**Step 2.** The total boom output needed in gallons per minute is given in Equation 7.

(Equation 7) Boom output (GPM) = acres per minute × gallons per acre

**Step 3.** To find the GPM per nozzle or device, divide the boom output by the number of nozzles you wish to use. From the GPM and label information, select the nozzle type and size that will give the output within the desired pressure range.

### *Calibration Procedure*

**Step 1.** Install the selected nozzles on the boom. Use water to check the nozzles for uniform distribution. When the nozzles are working properly, check the output of each nozzle at a convenient pressure. Replace any nozzles that are not within 5 percent of the average output.

**Step 2.** Adjust the pressure until you obtain the output per nozzle calculated in Step 3 under *Nozzle Tip Selection* (page 32). If the pressure is too high or low when this output per nozzle is obtained, select another nozzle size and recalibrate.

**Step 3.** Using water and a dye such as food coloring, spray one pass across a strip of adding machine paper or other white surface to check distribution and swath width. Spray into or with the wind at the height you intend to fly. Adjust your nozzle spacing, release height, etc. until a uniform distribution is obtained. From the deposits, determine the swath width.

**Step 4.** Using a paper strip three times as long as that used in Step 3, make three passes back and forth across the paper with the swath spacing from Step 3. If the resulting swath spacing is incorrect, change the spacing until the swath width is satisfactory. During these tests, check your ground speed. If it is not the speed you used in Step 1, adjust the speed until it is correct and recalibrate, using this new ground speed.

**Step 5.** Use Equations 8, 9, and 10 to determine how many acres you can cover per tank and how many passes can be made in a field of given length.

(Equation 8) Acres per load =

$$\frac{\text{tank capacity (gallons)}}{\text{gallons per acre (GPA)}}$$

(Equation 9) Acres per pass =

$$\frac{\text{swath width (feet)} \times \text{field length (feet)}}{\text{43,560 (square feet per acre)}}$$

(Equation 10) $$\text{Passes per load} = \frac{\text{acres per load}}{\text{acres per pass}}$$

Once you have used a set of nozzles and know their performance, you do not need to repeat the above procedure each time, but make sure that you replace the nozzles as they wear or lose their pattern so that the performance remains consistent.

## AERIAL DUSTERS AND GRANULAR APPLICATORS

Aerial dusters and granular applicators include dust, impregnated granules, solid fertilizers, and seeds. For the finer materials (smaller than 60-mesh), some agitation may be necessary in the hopper to prevent bridging. Since most commercial granules contain fines (dust), the seals between the components of the equipment (the tank, metering gate, and disseminator) require frequent inspection to make sure that there are no leaks. Seal strips that look mechanically tight on the ground will often leak under the influence of air pressures developed in flight.

The size, shape, and weight of the particles and the "flowability" of the pesticide affect the swath width, the application rate, and the pattern. Common effective swath widths are 35 to 40 feet when applied at a 10- to 15-foot altitude. Some disseminators at low application rates achieve satisfactory swath widths of 50 feet.

### Use and Maintenance

Good preventive maintenance procedures will keep many problems such as sticking gates, poor feeding, etc. from developing. Observe the same precautions listed under *Aerial Sprayers* (page 36). Don't overestimate your swath. Lateral distribution of dry pesticides is difficult at the air speeds used.

### Calibration

It is difficult to calibrate dry spreaders upon the ground, but the spinner types can be tested on the ground by refilling the hopper or catching and weighing the output. Ram-air types require testing in flight. New systems of all types should be flight-tested, using untreated dry materials to determine settings for various outputs and swath widths and patterns. Large buckets or cans should be used on two-foot centers to catch outputs as single and triple passes are made.

With these tests as a basis, tentative settings can be used for the actual pesticide application. Equation 5 (page 34) can then be used to verify or adjust the application rate during the first few passes on a new job.

An accurate means for marking swaths should be used with all aerial applications. The pilot should turn far enough beyond the end of the field so that he is at the proper spray height for turning on the sprayer when he returns to the field. If obstacles force pulling up early or dropping late, he should make sure that dispersal is only in level flight. Treat the areas missed by applying swaths crosswise. When in doubt about weather conditions permitting a safe application, halt operations until conditions improve.

# CHAPTER SIX: PESTICIDES IN THE ENVIRONMENT

To prevent adverse effects to the environment when applying pesticides, you must be aware of four basic considerations. First, the entire environmental system (ecosystem) is so complex that the seemingly minor action of using a pesticide against a pest species may have unexpected effects on other sections of the ecosystem. Second, because a pesticide is a poison, it may harm species other than the pest against which it is used. Third, some pesticides may move to a point far from the location where they were applied, and may be concentrated in the bodies of certain animals. Fourth, some pesticides persist long enough to cause damage at a later time and at a location not intended in the original application.

## MOVEMENT OF PESTICIDES

Pesticides become problems when they move off target — drifting out of the target area; moving through soil runoff or erosion; and leaching through the soil or being carried out as residues in the air, as well as in plants and animals. Pesticides should not be allowed to move off target, and they should be applied in such a manner and at such a time that they will do the least damage to beneficial organisms in the treated area.

### Soil Movement

Pesticides attached to soil particles can be carried out of the target area by soil erosion caused by rain and wind. Particles of soil with attached pesticides can be washed into streams, resulting in contamination of water and injury to plant and animal life.

Certain pesticides are so attracted to the soil that they do not move down through the soil layers, while other materials can be leached several feet into subsoil layers. Most pesticides that become attached to soil do not usually move far from the point of application. Bacteria and other microscopic organisms in the soil are important in the chemical process of breaking down the pesticides into nontoxic forms.

### Air Movement

Pesticide drift is the movement of spray or dust particles or chemical vapors a considerable distance from the place of release or discharge. Drift can damage crops, injure livestock, leave residues on crops and livestock, pollute the environment, and poison humans.

The most important causes of pesticides moving out of the target area are weather and the size of the particles. Usually, pesticides should not be applied when the wind is blowing faster than 7 miles per hour. A weather condition called "inversion," where warm air overhead traps cool air beneath can cause air movement and drift. Inversions usually occur in early morning or late afternoon.

High nozzle pressure reduces the size of the spray particles, causing additional drift. Even when fairly high pressures are necessary to obtain effective coverage, you can minimize drift by avoiding higher-than-recommended nozzle pressures.

Unlike spray or dust drift, vapor drift is directly related to the chemical properties of the pesticide. Vapor drift can result from vapor leakage. Properly sealing fumigants or other volatile materials after they are applied and using vaportight equipment will prevent vapor leakage. Many volatile pesticides cause safety problems from vapor drift. For example, ester formulations of phenoxy herbicides volatilize and drift when the temperature is high. Amine or acid formulations should be used.

### Water Movement

Most pesticide movement through soil or air ends up in water. Water can be contaminated by applying the wrong pesticide when attempting to control mosquitoes, blackfly larvae, fish, etc.; applying the pesticide directly to water through carelessness; drift; spills; and backsiphoning from the sprayer. "Empty" pesticide containers must be accounted for and returned to storage for disposal. Otherwise, they and the pesticide within them are likely to end up in the water. Leftover spray should never be emptied down a storm sewer. A storm sewer is a direct path to water.

Do not apply pesticides before a heavy rain. Heavy rains soon after application can wash pesticides from the target area and into water. Pesticides may also reach water by leaching through the soil, but leaching is not a major source of contamination.

To bring about a reduction of environmental pollution, you should use biodegradable pesticides whenever possible. You should also avoid drift; avoid applying pesticides in close proximity to ponds, lakes, or streams; warn beekeepers of the date and time of day that you plan to spray; if possible, avoid applying pesticides when crops are blooming (if it is necessary to spray blooming crops when bees are present, spray late in the afternoon and use a highly biodegradable insecticide); store and dispose of pesticides properly; and avoid using excessive amounts of pesticide.

## PERSISTENCE OF PESTICIDES

Pesticides act in different ways after they are applied. Most pesticides can be classified into one of the following four categories:

(1) **Pesticides that break down rapidly** remain on the target or in the environment only a short time before being changed into harmless products. Some are highly toxic; others are relatively harmless. All of them can be safe for the environment if used properly.

(2) **Accumulative pesticides** can build up or accumulate in the bodies of animals and humans. They may build up until they are harmful to the individual organism or to the consumer of the organism.

(3) **Pesticides that break down slowly** are called **persistent** pesticides. Persistency is often a desirable characteristic for long-term control of pests. Usually, persistent pesticides do not react readily with sunlight, oxygen, or heat; are not broken down easily by soil microorganisms; are only slightly soluble in water; and may remain in the environment for months or years. Persistent pesticides do not always accumulate. Some pesticides remain in the soil but do not seem to build up in the bodies of animals. Although these pesticides can injure sensitive crops planted in the same soil the next year, they seem to be of little hazard to the environment outside the treated area.

(4) **Pesticides that are both persistent and accumulative** can be hazardous if you allow them to escape from the target area. They may remain in the soil, water, or on the target area long enough so that the nontarget plants or animals are exposed to them.

**Food chain** is a term describing how all organisms depend upon one another. Each animal's place in this chain depends upon the type of food the animal eats. Animals that eat only plants are at the bottom of the chain, and animals that eat meat are at the top. Even if one organism is not affected by a pesticide, another animal in the food chain may be harmed.

Meat eaters feeding on animals that have accumulated pesticides may be poisoned without directly contacting the pesticide. Man, as both a plant and meat eater, could get high doses of pesticide in this way, although he is usually protected by residue tolerances.

**Biological magnification** is a term describing the concentration of pesticides at the top of the food chain.

### Persistence of Common Insecticides

The persistence of an insecticide includes the period of time that the insecticide residue is active, plus the time that the insecticide persists in significant enough amounts to control insects. Residue below .005 ppm is considered zero, since this is about the lowest level that most insecticides can be accurately determined through chemical analysis.

Because of longer persistence, fewer applications of an insecticide may be necessary to achieve satisfactory control. This advantage is offset by the fact that long persistence increases the time that humans, animals, and plants are exposed to the pesticide. If the insecticide is bioaccumulative (accumulates in living organisms), there is an added disadvantage to persistency. If an insecticide is biodegradable (breaks down in living organisms), long persistence is not of primary concern.

Major influences affecting the breakdown of insecticides in and on plants, animals, and the environment are temperature, moisture, pH, sunlight, organic matter, enzymes, and microorganisms. Most insecticides are relatively insoluble in water, and if present, are found primarily at the bottom.

It is impossible to state the exact length of time that a particular insecticide will persist. Varying climatic and physical conditions, the type of formulation, the amounts of active ingredient applied, etc. affect the length of persistence. Table 5 shows the persistence, bioaccumulativity, and biodegradability of some common insecticides. The time intervals shown are for the period that the insecticide is expected to be **insect-active** (IA) and the period for which a **significant residue** (SR) of the insecticide is expected to remain after application. The persistence ranges are based upon a single application of the most commonly used rate of the insecticide. These figures are estimates, and are intended to serve only as a comparative guide.

Frequently, a waiting period is required after an insecticide has been applied to a crop or livestock before the crop can be harvested or the livestock slaughtered for food or feed. This waiting period allows sufficient time for residues of the insecticide to decrease so that the residue is less than the legally allowable amount or tolerance. Waiting periods may vary for the same insecticide, depending upon the crop, rate of application, or other conditions. Be sure to follow the label on the container for each specific use.

## Persistence of Common Herbicides

Persistence is the length of time that a herbicide remains active in the soil. Persistence is desirable for long-term total vegetation control or full-season weed control. It is undesirable, however, when the herbicide leaves a residual toxicity or carryover to damage succeeding susceptible crops.

Anything that affects the rate of disappearance or loss of activity of an herbicide will affect its persistence. The processes involved in loss or degradation of herbicides are volatility (gaseous loss); photodecomposition (caused by sunlight); adsorption (binding on colloids); leaching (movement through the soil); microbial decomposition; chemical decomposition; and plant uptake.

Volatility and photodecomposition are surface phenomena, and herbicides that are subject to these processes are usually incorporated. Soil texture and organic matter influence the amount of adsorption. Rainfall determines the rate of leaching, and temperature, moisture, soil pH, and fertility affect the rate of microbial and chemical decomposition.

Herbicides differ in their persistence. Those chemicals that are highly adsorbed or slowly degraded are the most likely candidates for long-term vegetation control. Unfortunately, they are also the most likely candidates for carryover. The following persistent herbicides are either soil sterilants at high rates or have caused carryover problems to succeeding crops.

**Benzoic acids**.....**2,3,6-TBA, Banvel**
**Dinitroanilines**.....**Treflan, Tolban**
**Phenylureas**.....**Monuron, Telvar, Spike, Tandex**
**S-triazines**.....**AAtrex (atrazine), Princep, Pramitol**
**Uracils**.....**Hyvar X, Sinbar**
**Inorganics**.....**borates, arsenates, arsenites**
**Others**.....**Fenac, Tordon, Casoron**

Both accurate calibration and even distribution are essential because application rate and uniformity affect the localized concentration. You must know how much herbicide to apply and how to apply it.

Wettable powders or suspension concentrates require thorough agitation to assure homogeneous mixing as well as even output. Some emulsifiable concentrates do not emulsify in fluid fertilizers, and these also require thorough agitation. Many cases of herbicide carryover are caused by too much overlap of broadcast application patterns or from dripping nozzles when the sprayer is stopped.

The use of long-term soil sterilants is undesirable on sloping ground where the herbicide may be carried to desirable vegetation and on the bare ground of slopes subject to erosion.

Table 6 shows the persistence of common herbicides in medium-textured soil under normal conditions in Illinois. The common names of the herbicides are those approved by the Weed Science Society of America.

---

*(Tables 5 and 6 appear on the following three pages.)*

*Table 5. Persistence, Bioaccumulativity, and Biodegradability of Common Insecticides (dashes indicate that the insecticide is not used for a particular purpose)*

| Insecticide | Trade name | Persistence | | | | | | | | | | | | | | Bio-accumulativity | Bio-degradability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Soil | | Water | | Plants | | Animals | | Stored products | | Inside structures | | Outside structures | | | |
| | | IA | SR | IA | SR | IA | SR | IA | SR | IA | SR | IA | SR | IA | SR | | |
| acephate | Orthene | — | — | — | — | 1-2 wk | 3-5 wk | — | — | — | — | — | — | — | — | none | high |
| aldrin | | 1 yr+ | 1 yr+ | — | — | — | — | — | — | — | — | — | — | — | — | high | low |
| Aramite | | — | — | — | — | 1-4 wk | 1-6 mo | — | — | — | — | — | — | 1-7 da | 1-4 wk | medium | medium |
| azinphosmethyl | Guthion | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| *Bacillus thuringiensis* | | — | — | — | — | 1-4 wk | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| biothion | Abate | — | — | 1-4 wk | 1-4 wk | — | — | — | — | — | — | — | — | — | — | none | high |
| carbaryl | Sevin | 1-6 mo | 1-6 mo | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | — | — | none | high |
| carbofuran | Furadan | 1-6 mo | 1-6 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| carbophenothion | Trithion | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| chlordane | | 1 yr+ | 1 yr+ | — | — | 1-4 wk | 1-6 mo | — | — | — | — | 1-6 mo | 6-12 mo | 1-4 wk | 1-6 mo | high | low |
| chlorpyrifos | Dursban | 1-6 mo | 1-6 mo | 1-4 wk | 1-4 wk | 1-7 da | 1-4 wk | — | — | — | — | 1-4 wk | 1-6 mo | — | — | none | high |
| coumaphos | CoRal | — | — | — | — | — | — | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | — | — | none | high |
| crotoxyphos | Ciodrin | — | — | — | — | — | — | 1-7 da | 1-7 da | — | — | 1-7 da | 1-4 wk | — | — | none | high |
| cryfomate | Ruelene | — | — | — | — | — | — | 1-4 wk | 1-4 wk | — | — | — | — | — | — | none | high |
| DDT | | — | — | — | — | — | — | 1-4 wk | 1-6 mo | — | — | 1-6 mo | 6-12 mo | — | — | high | low |
| demeton | Systox | 1-4 wk | 1-6 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| diazinon | | 1-4 wk | 1-6 mo | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | none | high |
| diazinon + methoxychlor | Alfa-Tox | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | low | high |
| dichlorvos | DDVP | — | — | — | — | — | — | 1 da | 1-7 da | 1 da | 1-7 da | 1 da | 1-7 da | 1 da | 1 da | none | high |
| dicofol | Kelthane | — | — | — | — | 1-4 wk | 1-6 mo | — | — | — | — | — | — | — | — | medium | medium |
| dieldrin | | 1 yr+ | 1 yr+ | — | — | 1-4 wk | 1-6 mo | 1-4 wk | 1-6 mo | — | — | 1-6 mo | 6-12 mo | 1-4 wk | 1-6 mo | high | low |
| dimethoate | Cygon | — | — | — | — | 1-4 wk | 1-4 wk | — | — | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | none | high |
| disulfoton | Di-Syston | 1-4 wk | 1-6 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| endosulfan | Thiodan | — | — | — | — | 1-4 wk | 1-6 mo | — | — | — | — | — | — | — | — | medium | low |
| endrin | | — | — | — | — | 1-4 wk | 1-6 mo | — | — | — | — | — | — | — | — | high | low |
| EPN | | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| ethion | | 1-4 wk | 1-6 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| ethoprop | Mocap | 1-6 mo | 1-6 mo | — | — | — | — | — | — | — | — | — | — | — | — | none | high |

da = days; wk = weeks; mo = months; yr = years.
IA = insect-active. The time periods shown are those in which the insecticide remains insect-active.
SR = significant residue. The time periods shown are those in which a significant residue of the insecticide remains following application.

*Table 5. Continued*

| Insecticide | Trade name | Persistence | | | | | | | | | | | | | | Bio-accumulativity | Biodegradability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Soil | | Water | | Plants | | Animals | | Stored products | | Inside structures | | Outside structures | | | |
| | | IA | SR | IA | SR | IA | SR | IA | SR | IA | SR | IA | SR | IA | SR | | |
| fensulfothion | Dasanit | 1-6 mo | 1-6 mo | — | — | — | — | — | — | — | — | — | — | — | — | none | high |
| fenthion | Baytex | — | — | 1-4 wk | 1-4 wk | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | 1-6 mo | 1-6 mo | 1-7 da | 1-4 wk | none | high |
| fonofos | Dyfonate | 1-6 mo | 1-6 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| heptachlor | | 1 yr+ | 1 yr+ | — | — | — | — | — | — | — | — | — | — | — | — | high | low |
| lead arsenate | | — | — | — | — | 1-4 wk | 1-6 mo | — | — | — | — | — | — | — | — | high | low |
| lindane | | 6-12 mo | 1 yr+ | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | high | low |
| malathion | | — | — | 1-7 da | 1-4 wk | 1-7 da | 1-7 da | 1-7 da | 1-4 wk | 6-12 mo | 1 yr+ | 1-4 wk | 1-4 wk | 1-7 da | 1-7 da | none | high |
| methidathion | Supracide | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| methomide | Monitor | — | — | — | — | 1-4 wk | 1-6 mo | — | — | — | — | — | — | — | — | none | high |
| methomyl | Lannate | — | — | — | — | 3-7 da | 1-2 wk | — | — | — | — | — | — | — | — | none | high |
| methoxychlor | | 1-6 mo | 6-12 mo | — | — | 1-4 wk | 1-6 mo | 1-4 wk | 1-4 wk | 6-12 mo | 1 yr+ | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | low | medium |
| methylparathion | | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| mevinphos | Phosdrin | — | — | — | — | 1 da | 1-7 da | — | — | — | — | — | — | — | — | none | high |
| naled | Dibrom | — | — | — | — | 1 da | 1-7 da | 1 da | 1-7 da | — | — | 1 da | 1-7 da | 1 da | 1 da | none | high |
| nicotine | | — | — | — | — | 1-7 da | 1-4 wk | — | — | — | — | 1-7 da | 1-7 da | — | — | none | high |
| parathion | | 1-6 mo | 6-12 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| phorate | Thimet | 1-6 mo | 1-6 mo | — | — | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| phosmet | Imidan | — | — | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | — | — | — | — | none | high |
| propoxur | Baygon | — | — | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | none | high |
| pyrethrin | | — | — | 1-7 da | 1-7 da | 1 da | 1-7 da | 1 da | 1-7 da | 1-6 mo | 6-12 mo | 1 da | 1-7 da | 1 da | 1 da | none | high |
| ronnel | Korlan | — | — | — | — | — | — | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | none | high |
| rotenone | | — | — | 1 da | 1-7 da | 1-7 da | 1-4 wk | — | — | — | — | — | — | — | — | none | high |
| stirifos | Rabon | — | — | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | — | — | — | — | none | high |
| terbufos | Counter | 1-6 mo | 1-6 mo | — | — | — | — | — | — | — | — | — | — | — | — | none | high |
| toxaphene | | 1-6 mo | 6-12 mo | — | — | 1-4 wk | 1-6 mo | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | medium | medium |
| trichlorfon | Dylox | — | — | — | — | 1-7 da | 1-4 wk | 1-4 wk | 1-4 wk | — | — | 1-4 wk | 1-6 mo | 1-7 da | 1-4 wk | none | high |

da = days; wk = weeks; mo = months; yr = years.
IA = insect-active. The time periods shown are those in which the insecticide remains insect-active.
SR = significant residue. The time periods shown are those in which a significant residue of the insecticide remains following application.

*Table 6. Persistence of Common Herbicides*

| Common name | Trade name | Pounds of active ingredient per acre | Application[a] | Months of persistence |
|---|---|---|---|---|
| alachlor | Lasso | 2-4 | PPI, PrE | 1½-3 |
| ametryn | Evik | 2-2½ | PoE | 1-3 |
| amitrole | many | 2-10 | PoE | ½-1 |
| atrazine | AAtrex, atrazine | 1-4 | PPI, PrE, PoE | 2-12 |
| atrazine | AAtrex, Atratol | 4-12 | PrE-NS | 6-24 |
| benefin | Balan | ¾-1½ | PPI, PrE | 4-12 |
| benzulide | Betasan, Prefar | 4-6 | PrE | 3-12 |
| bentazon | Basagran | ¾-1 | PoE | 0-1 |
| bifenox | Modown | 1½-2 | PrE | 1½-2 |
| bromacil | Hyvar-X | 4-20 | PrE | 3-24 |
| butralin | Amex | 1½-3 | PPI | 4-8 |
| butylate | Sutan+ | 2-6 | PPI | 1-4 |
| chloramben | Amiben, Vegiben | 2-3 | PrE | 1-2 |
| chlorbromuron | Maloran | 1-4 | PrE | 2-6 |
| chlorsuron | Tenoran | 1-4 | PoE | 1-4 |
| chlorpropham | Furloe Chloro IPC | 2-8 | PrE | ½-1 |
| cyanazine | Bladex | 1-4 | PPI, PrE, PoE | 1-4 |
| 2,4-D | many | ¼-3 | PrE, PoE | ½-1 |
| dalapon | Dowpon, Basfapon | 5-10 | PoE | ½-1 |
| 2,4-DB | Butoxone, Butyrac | ½-1 | PoE | ½-1 |
| DCPA | Dacthal | 6-10 | PrE | 2-6 |
| dicamba | Banve | ½-4 | PrE, PoE | 2-16 |
| dichlobenil | Casoron | 2-6 | PrE, PoE | 2-6 |
| dinitramine | Cobex | ½-¾ | PPI | 3-4 |
| dinoseb | Premerge, Sinox | 1½-9 | PrE, PoE | ½-2 |
| diphenamid | Dymid, Enide | 4-6 | PrE | 4-12 |
| diuron | Karmex | 1-4 | PrE | 3-12 |
| diuron | Karmex | 5-6 | PrE-NS | 6-24 |
| EPTC | Eptam, Eradicane | 2-8 | PPI | 1-3 |
| fluchoralin | Basalin | ½-1 | PPI | 4-12 |
| glyphosphate[b] | Roundup | ¾-4 | PoE | 0-1 |
| linuron | Lorox | ½-3 | PrE, PoE | 2-6 |
| metolachlor | Dual | 1-3 | PPI, PrE | 2-4 |
| metribuzin | Lexone, Sencor | ¼-1 | PPI, PrE | 1-4 |
| naptalam | Alanap | 2-8 | PrE | 1-2 |
| nitrofen | TOK | 3-6 | PoE | 1-2 |
| oryzalin | Surflan | ½-1¼ | PrE | 4-12 |
| paraquat[b] | Paraquat | ½-1 | PoE | 0-1 |
| pendimethalin | Prowl | 1-2 | PPI, PrE | 4-8 |
| picloram | Tordon | ¼-2 | PoE | 3-24 |
| procyazine | Cycle | 1-4 | PrE, PoE | 1-3 |
| profluralin | Tolban | ½-1 | PPI | 4-12 |
| prometone | Pramitol | 10-25 | PrE-NS | 6-24 |
| pronamide | Kerb | 1-2 | PrE | 2-4 |
| propachlor | Bexton, Ramrod | 4-6 | PrE | 1-2 |
| pyrazon | Pyramin | 4-12 | PrE | 1½-3 |
| silvex | Kuron, 2,4,5-TP | 1-3 | PoE | 1-4 |
| simazine | Princep | 1-4 | PPI, PrE | 3-15 |
| simazine | Princep | 5-40 | PrE-NS | 6-24 |
| 2,4,5-T | many | 1-3 | PoE | 1-4 |
| 2,3,6-TBA | Benzac, Trysben | 4-20 | PrE, PoE | 6-24 |
| terbacil | Sinbar | ½-3¼ | PrE | 3-15 |
| trifluralin | Treflan | ½-2 | PPI | 4-12 |
| vernolate | Vernam | 2-4 | PPI, PrE | 1-2 |

[a] PPI = preplant incorporated; PrE = preemergence; PoE = postemergence; NS = nonselective.
[b] Present in soil but inactive.

# CHAPTER SEVEN: INSECTS, INSECT RELATIVES, RODENTS, AND BIRDS

## INSECTS AND INSECT RELATIVES

### Insects

There are both useful and destructive insects. Useful insects include the following: insects that are predators and parasites of other insects; insects that destroy various weeds; certain scale insects used for making dyes and shellac; silkworms; honeybees and some wild bees that act as plant pollinators and produce honey; insects that serve as food for animals; insects used for medicinal purposes; and insects that serve as scavengers by eating decaying organic matter.

Common destructive insects include the European corn borer, true armyworm, corn earworm, some grasshoppers, codling moth, cabbage looper, certain flea beetles, gypsy moth, bagworm, tent caterpillars, lawn webworms, biting flies, housefly, mosquitoes, lice, fleas, termites, and roaches. Destructive insects damage food, feed crops, and livestock, and are our greatest rival for available food. They also damage structures; transmit certain diseases to humans, animals, and plants; irritate humans and animals by their bites, stings, and toxic hairs; and are a general nuisance.

Before applying a control measure for an insect, you must first identify the insect and understand its life cycle. If you need help in identifying a particular insect, consult your county extension adviser.

True insects are characterized by having three pairs of jointed legs and three distinct body regions — the head, thorax, and abdomen. The wings (one or two pairs), if present, arise from the thorax. The mouthparts vary, ranging all the way from the primitive mouth hooks of maggots (larval stage of flies); to jaws or mandibles for chewing insects such as beetles and caterpillars (larval stage of moths and butterflies); to the more sophisticated sponging mouthparts of houseflies; to the piercing, sucking mouthparts of mosquitoes and biting flies; to the rasping, sucking mouthparts of thrips; to the lapping-sucking mouthparts of bees and wasps; and to the siphoning mouthparts of moths and butterflies.

Insects with **incomplete development** pass through the egg, nymph, and adult stages. Insects with **complete development** pass through the egg, larva (maggot, grub, caterpillar), pupa or resting stage (nonfeeding), and the adult stage. The larval, nymphal, and adult stages are the damaging ones. Insects such as beetles, flies, bees, and moths have a four-stage life cycle. Insects such as roaches, grasshoppers, crickets, leafhoppers, and aphids have a three-stage life cycle.

### Insect Relatives

Insect relatives include mites, ticks, spiders, centipedes, and millipedes.

**Mites** are spiderlike, and have four pairs of jointed legs as an adult. They are small (pinhead size), wingless, and soft-bodied. Mites attack both plants and animals. Plant injury caused by mites may be discovered before the mites are noticed. When mites are in large numbers, their feeding turns foliage and buds yellow and then brown, resulting in a russetting appearance. Some mites produce webs on plants.

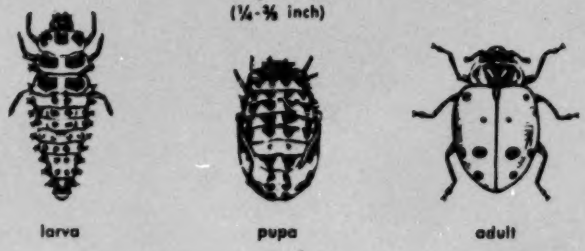
Like mites, **ticks** have four pairs of legs in the adult stage. Ticks are larger than mites, and their skin is leathery. They have mouthparts that are well developed for firmly attaching themselves to animals and humans. Ticks do not attack plants.

**Spiders** have four pairs of legs and two distinct body regions, and their mouthparts are of the sucking type. They vary in size from a fraction of an inch to 5 to 6 inches. Practically speaking, there are only two kinds of poisonous spiders in Illinois — the black widow spider and the brown recluse. Spiders feed only on other insects or insect relatives. They do not harm plants.

**Centipedes** ("the hundred leggers") are relatively fast-moving animals that feed on other insects and insect relatives. They have many body segments, and each segment has one pair of legs.

**Millipedes** ("the thousand leggers") are slow-moving animals that feed on decaying organic matter. They have two pairs of legs per body segment.

## USEFUL INSECTS



Lady beetle
(¼-⅜ inch)

larva pupa adult

Aphis lion
(½ inch)

Assassin bug
(½ inch)

Ground beetle
(¼-1½ inches)

Golden-eyed lacewing fly
(adult of aphis lion)
(1¼ inches)

Parasitic wasp
(⅛-2 inches)

Parasitic fly
(⅜ inch)

## DESTRUCTIVE INSECTS

Housefly
(¼ inch)

Seed-corn maggot

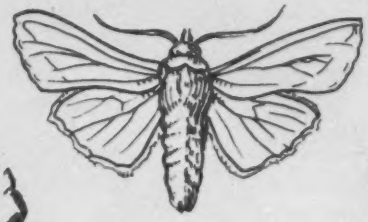
larva
(½ inch)

adult
(⅓ inch)

pupa
(⅓ inch)

Clover leaf weevil
(⅛ inch)

Bean leaf beetle
(¼ inch)



Armyworm moth
(1 inch)

Striped blister beetle
(⅝ inch)

Rice weevil
(3/16 inch)

Saw-toothed grain beetle
(⅛ inch)

Cabbage looper
(1½ inches)

Black carpet beetle larva
(½ inch)

White grubs
Underside of last abdominal segment (magnified)

Annual white grub
(1 inch)

no pattern to spines

White grub
(1 inch)

parallel rows of spines

Japanese beetle
(1 inch)

inverted V-shaped pattern

## DESTRUCTIVE INSECTS

American roach
(1½ inches)

Red-legged grasshopper
(1¼ inches)

Ant
(4/5 inch)

Termite worker
(¼ inch)

Termite soldier
(5/16 inch)

Chinch bug
(⅛ inch)

Pea aphid
(1/6 inch)

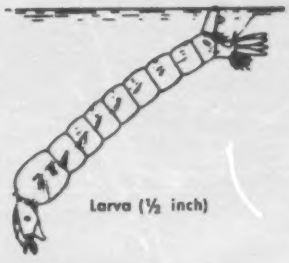
Potato leafhopper
(⅛ inch)

Flea
(⅛ inch)

Long-nose cattle
sucking louse
(1/16 inch)

Life stages of mosquito

Egg (1/40 inch)

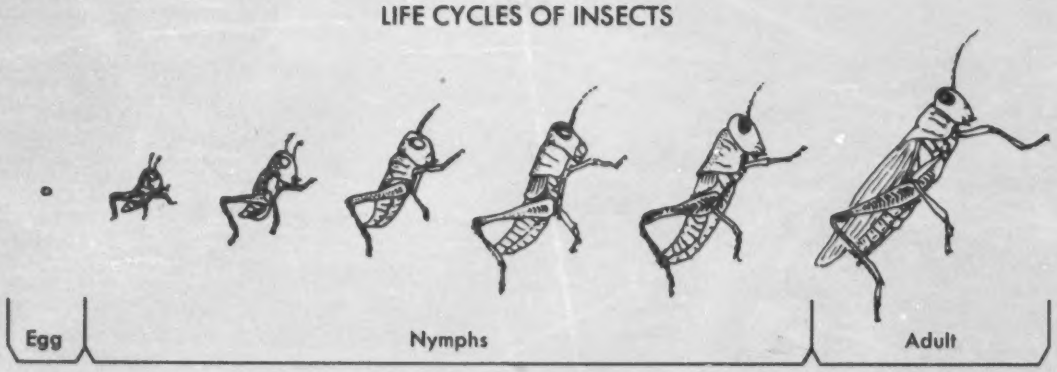


Larva (½ inch)

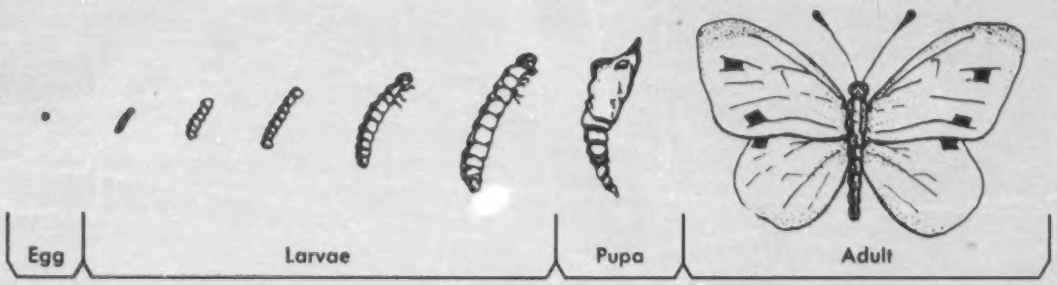
Pupa (⅜ inch)

Adult female (¼-½ inch)

## LIFE CYCLES OF INSECTS




Incomplete Development (Three-Stage Life Cycle)




Complete Development (Four-Stage Life Cycle)

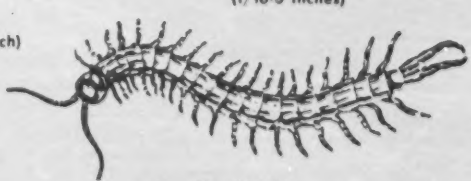
## INSECT RELATIVES

Mite
(1/16 inch)

Tick
(1/16-½ inch)

Spider
(1/16-3 inches)

Millipede
(½-1½ inches)



Centipede
(½-2½ inches)

### Control

The following methods are used to control insects and insect relatives:

(1) **Pesticides such as insecticides, attractants, repellents, and growth regulators.** In general, pesticides are still the most efficient means of controlling most insect outbreaks.

(2) **Cultural practices to make the environment unsuitable for insect development.** These may include rotation of corn with other crops to control corn rootworms, sanitation or the elimination of breeding material for fly and mosquito control, and good housekeeping practices to reduce the number of roaches and insects that infest fabrics.

(3) **Mechanical controls to exclude insects.** These may include screens to keep out flies and mosquitoes and traps to catch large numbers of insects. (Traps have not been generally successful in insect control.)

(4) **Resistant plant varieties to limit insect attack.** For example, resistant varieties of wheat have been highly successful in preventing damage from the Hessian fly.

(5) **The use of parasites, predators, and diseases.** Examples of this method are the use of lady beetles to control cottony cushion scale in California, and the *Bacillus thuringiensis* disease organism to control cabbage worms, bagworms, tent caterpillars, tomato hornworms, and others.

(6) **Plant, animal, and vehicle quarantines and inspections at national, state, and even local borders.** These control measures have helped greatly in preventing the entry and spread of destructive insects. Many of the common destructive insects were imported from other countries.

To determine whether you need to control an insect infestation, you should make the following evaluation:

(1) Estimate the level of the infestation (number of insects per plant, per square foot, etc.) and the amount of damage (percent of defoliation, percent of cut plants, etc.).

(2) Compare the infestation and damage levels to the best-known economic threshold level to decide whether control is justified.

(3) Determine the predominant stage and size of the insects. If most of the insects are full-grown larvae, they will soon pupate and no control may be necessary. If most of the larvae are only half-grown, however, they will continue to feed for some time, and control measures may be needed immediately.

(4) Be on the lookout for dead and dying insects (they indicate that a disease organism or parasite is at work) and large numbers of insect predators. Some diseases and parasitic insects can reduce insect populations below the level at which it is necessary to spray. The presence of insect predators such as lady beetles, insidious flower bugs, syrphid fly maggots, and aphis lions indicates that nature may soon solve the problem and no other control measures will be needed.

(5) Judge the length of time remaining before the crop is harvested or the livestock sent for slaughter. If the crop is within two weeks of harvest, it is usually best to harvest the crop early and, if necessary, apply a control to the succeeding crop.

(6) Consider the vigor of the plant or animals. If it appears that plants may grow away from the damage, then control may not be justified. If the plants are already under stress, however, even a lower insect infestation level may justify control.

If you decide to apply control measures, make your choice of the various methods from the recommendations of your county extension adviser, local pesticide dealer, vocational agriculture teacher, farm manager, insect pest management consultant, or an experienced pesticide applicator. You may wish to get several opinions.

## RODENTS AND BIRDS

### Control

The following methods may be used to control rodents and birds:

(1) **Sanitation.** Removing food, water, or cover so that the animal finds the area undesirable. An animal cannot live where the environment is unsuitable.

(2) **Exclusion.** Keeping animals out of an area through mechanical means. For example, sheet metal and hardware cloth will prevent rats from entering a corncrib.

(3) **Repellents.** Using repellents to frighten off or ward off animals. Birds may be frightened with a scarecrow. Rabbits can be repelled from shrubs with chemical taste repellents.

(4) **Population reduction.** Killing the animals that are causing damage through the use of traps or poison. Only a few pesticides used for controlling rodents and birds will kill on contact. Most of these chemicals are mixed with a food bait that the target animal must eat to be affected. The chemical must be effective and the bait must be edible.

## Rodenticides

In using a rodenticide, you should be familiar with the following characteristics:

(1) Toxicity, dosage level, and relative effectiveness.

(2) Degree of acceptance and reacceptance or the possible development of tolerances.

(3) Odor and taste.

(4) Solubility. Solubility influences bait-mixing techniques and the types of baits that can be used.

**Anticoagulants,** including diaphacinone, fumarin, pival, PMP, and warfarin are the rodenticides usually recommended for general public use. They are available in dry, ready-to-use baits or in soluble form in water baits. Baits that become caked, watersoaked, moldy, or insect-infested should be replaced promptly.

Prepared baits containing arsenic, phosphorus, and strychnine are commonly sold on the retail market. Use should be restricted to indoor protected stations out of the reach of children and pets. Barium carbonate, once recommended, is too weak to be effective. Thallium sulfate is extremely dangerous, and should be used only by professional operators. Sodium fluroacetate (Compound 1080) is not available to the general public, and its use is prohibited in Illinois.

Warfarin and fumarin belong to the group of chemicals known as *hydroxycoumarins*. Pival, diaphacinone, and PMP are known as *indandiones*. Both types of chemicals prevent the blood from clotting. The chemicals must be taken daily over a period of several days to be effective. Since repeated feedings are required, permanent, covered bait stations provide an excellent method of exposure to the rodent. Anticoagulants are effective against both rats and mice.

Although anticoagulants are exposed in such dilute mixtures that primary poisoning by accident requires the ingestion of an enormous quantity of bait, poisoning has occasionally occurred. A few cases of secondary poisoning have been reported as a result of pets feeding daily on dead or dying rats or mice. Some rats may not start feeding on the bait for a considerable time after exposure, or feeding may be intermittent, and two or three weeks may be necessary to produce results. It may require as long as 30 days for complete removal of a mouse colony.

**Zinc phosphide** is the most satisfactory of the single-dose poisons. It is not widely used because of its unavailability, offensive odor, and unattractive color. It is safer than many other poisons, however, because domestic animals will not eat baits prepared with it but rodents seem to like its pungent odor.

**Red squill** is one of the best known and least hazardous rodenticides for the untrained person to handle. It has a natural emetic value, and offers protection to animals capable of vomiting. Red squill is relatively distasteful and quite mild. So much squill must be included in the bait that some rats object to the taste and soon refuse it. Commercial production has been practically discontinued because of the poor quality of material offered for import. It is generally ineffective against house mice.

Used properly, **ANTU** will give good results against Norway rats, but it is ineffective against roof rats and house mice. For best results, ANTU should not be used more often than once every six months. Baits containing the material should not be left in place for more than three or four days.

Poisons are the most efficient and useful means for destroying rats and mice. Take full advantage of the particular characteristics of each of the rodenticides, and select those most likely to produce the desired results.

# CHAPTER EIGHT: PLANT DISEASES AND WEEDS

## PLANT DISEASES

Plant pathology is the study of plant diseases. A plant disease may be defined as a harmful alteration of the normal physiological and biochemical growth of the plant, or as a condition in which a plant differs from a normal (healthy) plant in either structure or function.

We can differentiate between plant diseases and nonparasitic injury by stating that a disease is usually a series of harmful processes that occur over a fairly long period of time, and injuries are disorders that occur over a short period of time.

The conditions necessary for a plant disease to occur are (1) a susceptible host plant; (2) a disease-producing agent; and (3) a favorable environment for development of the disease. If any one of these conditions is not met, a disease will probably not occur. The interaction of these three conditions is illustrated by the "disease triangle" on page 53.

Plant diseases are of two types — **noninfectious** and **infectious.** Noninfectious diseases are diseases that cannot be transmitted from plant to plant. They are caused by unfavorable growing conditions, such as weather, air pollutants, nutrient deficiencies or excesses, and toxicity. Infectious diseases are caused by agents (pathogens) that multiply and can be transmitted from plant to plant. These include fungi, bacteria, viruses, mycoplasmas, nematodes, and parasitic seed plants.

**Fungi** are microscopic plants that lack chlorophyll (green coloring). Most of the more than 100,000 species of fungi reproduce by spores. Some plant pathogenic fungi cannot survive in the soil for long periods, and can be controlled by soil fumigation, clean cultivation, and crop rotation. Other fungi are soil inhabitants, and cannot be controlled by these methods. Still other fungi must always be associated with a living plant.

For fungi that infect leaves, stems, flowers, or fruit, the host surface must usually be wet during spore germination and penetration. Soil-inhabiting fungi may or may not require wet soil.

Not all plant pathogenic fungi infect all plants. Some fungi attack only certain plants. Fungi are spread by rain, wind, insects, seed, farm implements, grafting, and runoff water or soil.

**Bacteria** are microscopic one-celled plants that reproduce by simple division. Assuming cell division every 20 minutes, bacterium can produce up to 70 billion offspring in 12 hours. Bacteria are spread primarily by water or by insects, and are generally favored by warm, rainy weather.

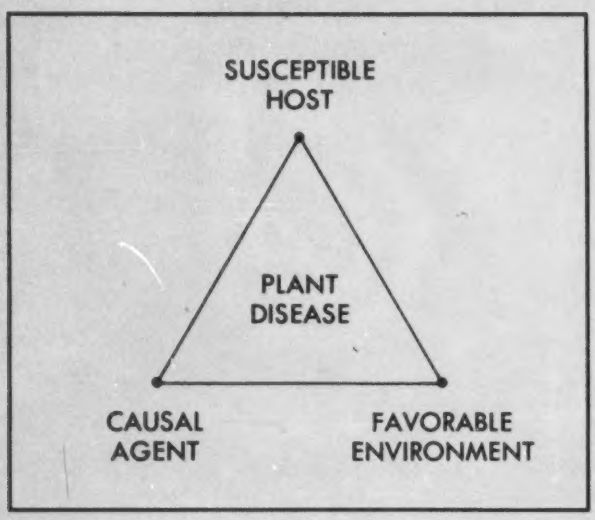
**Viruses** are perhaps the smallest forms of "life," and cannot be seen with an ordinary microscope. Viruses are usually spread by insects, plant propagation, seed, and workers' hands. In a few cases, soil-inhabiting fungi or nematodes may play a role in virus spread. Aphids or leafhoppers are the vectors (insect carriers) most commonly involved in virus transfer.

**Mycoplasmas** are a form of life somewhat intermediate between viruses and bacteria. Mycoplasmas are viruslike but more similar to bacteria in size and shape. They are transmitted by leafhoppers, and are often the causal agents of the "yellows" type of diseases that were thought to be caused by viruses until a few years ago.

**Plant-parasitic nematodes** are microscopic roundworms that feed most commonly on the roots of plants but may feed on the stems, leaves, or flowers. They are **obligate parasites** — that is, they can live only on living plants. Nematodes reproduce by eggs, and they are spread by anything that moves nematode-infected plant parts or infested soil.

Nematodes feeding on plant roots reduce plant vigor and growth, and may interact with soil-inhabiting fungi to cause a root-disease complex that results in more severe disease than either the nematode or fungus acting alone.

**Plant-parasitic plants** such as dodder, the true and dwarf mistletoes, and Striga are obligate parasites. Like most other plants, they reproduce by seed, and are spread from place to place by land animals and birds, wind, soil, or as contaminants in seed lots.




## Identification

To identify plant diseases correctly, you must carefully observe the symptoms of the disease and the signs of the causal agent. The symptoms are usually of the following three types: (1) **Overdevelopment of tissues** — galls, swellings, leaf galls, etc. Examples are crown gall, root-knot nematode, and peach leaf curl. (2) **Underdevelopment of tissues** — stunting, lack of chlorophyll, or incomplete development of organs. Examples are nematode damage to roots, aster yellows, and tobacco mosaic virus. (3) **Death of tissues** — leaf or flower blights, leaf spots, root rots, cankers, wilting, etc. Examples are Botrytis blight, Helminthosporium leaf spots, Phytophthora root rot, Cytospora canker, and Verticillium wilt.

It is helpful to observe the distribution of the diseases within the field or on the plant. In the early stages, infectious diseases rarely affect entire fields. They usually affect scattered plants or groups of plants within a field. Injuries of various types occurring suddenly and uniformly over a field are more likely to be caused by noninfectious disease-causing agents.

Signs of plant pathogens are structures or parts of the pathogen itself. These may be fungal spores, spore-producing bodies, nematodes, bacterial ooze, flowers and seeds of parasitic plants, etc. In most cases, a magnifying lens or microscope will aid in identification.

## Control

In attempting to control a plant disease, it is helpful to remember the three conditions necessary for a disease to occur: a susceptible host plant, a disease-producing agent, and a favorable environment for development of the disease. In selecting a control, consider the cost of the treatment and the life cycle of the pathogen.

Plant disease control can be classified into four basic methods: avoidance, exclusion, eradication, and protection.

**Avoidance.** Plant diseases can be avoided by planting disease-resistant varieties, selecting planting sites free of the pathogen or unsuited to disease development, sanitation, crop rotation, choice of planting date, or by propagating and planting only disease-free material.

**Exclusion.** Plant diseases can be excluded from certain areas by quarantines, inspections of plant materials, seed certification, and other methods used to prevent movement of pathogens.

**Eradication.** Plant pathogens can be eradicated and insect vectors can be controlled by pesticides (such as soil fumigants) and heat treatment, or by removal of infected plants or plant parts.

**Protection.** Plants can be protected from diseases by the application of protectant pesticides, through proper growing conditions, and by altering the environment to make it unfavorable for the pathogen to develop or multiply.

In most cases, diseases are not controlled by any one of the above methods but by the careful *integration* of these methods. In general, the best disease control program is disease prevention.

A dealer or applicator must never make a recommendation to a customer until he is absolutely sure that he has identified a disease correctly. If he has any doubt, he should contact his county extension adviser. If the adviser does not have the answer, then an extension plant pathology specialist should be consulted.

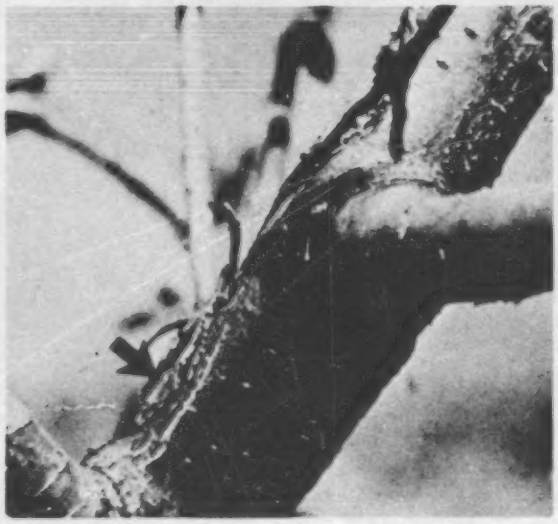
*(Some common plant diseases are described and illustrated on pages 54-59.)*

## SULFUR DIOXIDE

Symptoms of ozone and sulfur dioxide injury on pinto bean leaves. Left, leaf injured by ozone; center, healthy leaf; right, leaf damaged by sulfur dioxide.

Sulfur dioxide causes a noninfectious disease in certain plants. It is perhaps the most common air pollutant in the smoke from factories, and can injure vegetation in concentrations as low as .25 or one ppm. The first symptom is the watersoaked appearance of the leaves. Following the onset of this symptom, the cells collapse and dry out rapidly, leaving scalded or scorched areas. Mild attacks will merely cause the leaves to turn yellow. Middle-aged leaves are the most susceptible to sulfur dioxide; the young growing leaves are markedly resistant. The only known control for sulfur dioxide injury is to reduce the amount of sulfur dioxide in the air.

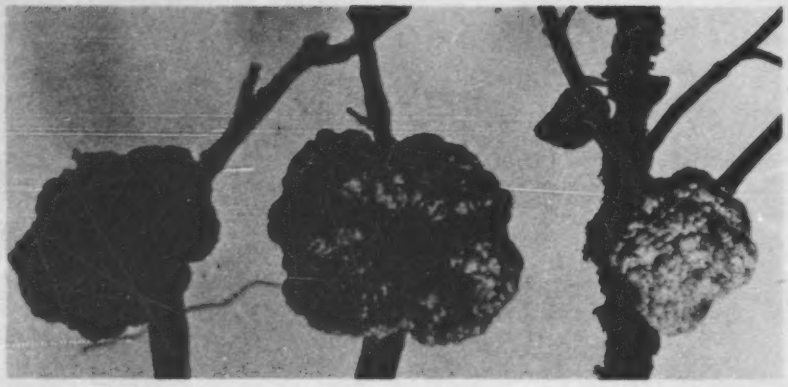
## FIREBLIGHT



Left, fireblight on the terminal twig of an apple tree. Note the "shepherd's crook" at the top of the photo. This is a typical symptom of the disease. Right, overwintering canker containing fireblight bacteria.

Fireblight is a common bacterial disease on apple, pear, quince, hawthorn, and mountain ash trees, and on cotoneaster and pyracantha shrubs. The bacterium is spread by splashing water or insects, and is favored by warm, rainy weather. The disease is controlled by pruning out diseased tissue (sanitation), by protective applications of bactericides such as streptomycin or copper, by the use of resistant varieties, and by avoiding excessive fertilization.

## CROWN GALL



Crown gall tumors on euonymus. Left, old gall; center and right, young galls.

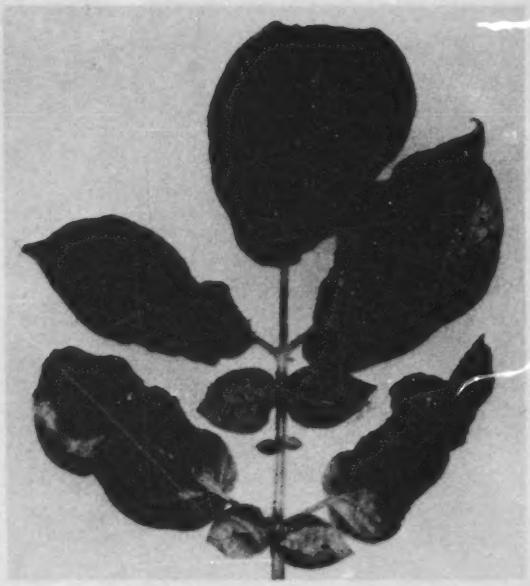
Crown gall is a bacterial disease of many woody plants. The host range includes over 142 genera. The disease is common on apple, blackberry, cottonwood, euonymus, grape, honeysuckle, poplar, raspberry, rose, willow, etc. The bacterium survives in infected tissue in the soil for many years. Infection can take place only through fresh wounds. Crown gall is controlled by removing infected plants or plant parts, avoiding infested soil and wounding, and by applying a disinfectant to cut surfaces such as grafting or budding wounds.

## DAMPING-OFF

Damping-off of salvia. Left, plants killed by the disease; right, weakened and healthy plants.

Seedling blights or damping-off are common on all young plants, especially when soils are wet and conditions do not favor rapid plant growth. Damping-off is caused by a large number of soil-inhabiting fungi, including *Pythium*, *Rhizoctonia*, *Fusarium*, and *Botrytis* species. Damping-off may be controlled in the greenhouse by planting in sterilized (pasteurized) soil, avoiding excessive moisture, providing proper conditions for plant growth, planting disease-free seed, and by using seed-treatment fungicides and fungicide soil drenches.

## LATE BLIGHT OF POTATO



Left, white mold growth on underside of leaf. This growth is a diagnostic sign for potato late blight. Right, advanced stage of the disease. Leaves are dark brown to black and shriveled.

Potato late blight is a fungal disease favored by cool, wet weather. The fungus overwinters on potato tubers, and is spread by planting infected tubers or by windblown spores. Potato late blight is controlled in stored potatoes by eliminating infected tubers. Seed certification programs play an important role in eliminating seed lots with infected tubers. The disease is controlled in the field by planting resistant varieties, or by periodic applications of protective fungicides.

## NORTHERN CORN LEAF BLIGHT

Typical symptoms: lesions are elongated light areas with tapered ends; they contain the fruiting bodies of the fungus (black dots in photo).

Northern corn leaf blight is a fungal disease favored by warm, wet weather. It is not as common today as it once was because of the extensive use of resistant hybrids. The causal fungus cannot survive in soil, and plowing down crop debris so that it rots is a good cultural control.

## VERTICILLIUM WILT

Verticillium wilt of tomato. Left, dead leaf resulting from verticillium infection; right, stem showing brown vascular discoloration.

Verticillium wilt is a common fungal disease of vegetables (tomato, pepper, eggplant, potato, etc.); bramble and tree fruits; many flowers; and woody plants (maple, redbud, tulip tree, rose, etc.). Diagnostic symptoms include wilting, yellowing and browning of foliage, and vascular discoloration. The fungus survives for long periods in the soil, and can be controlled by soil fumigation, avoiding infested land, and by the use of resistant varieties.

## POWDERY MILDEW

Rose leaf showing typical growth of a powdery mildew fungus.

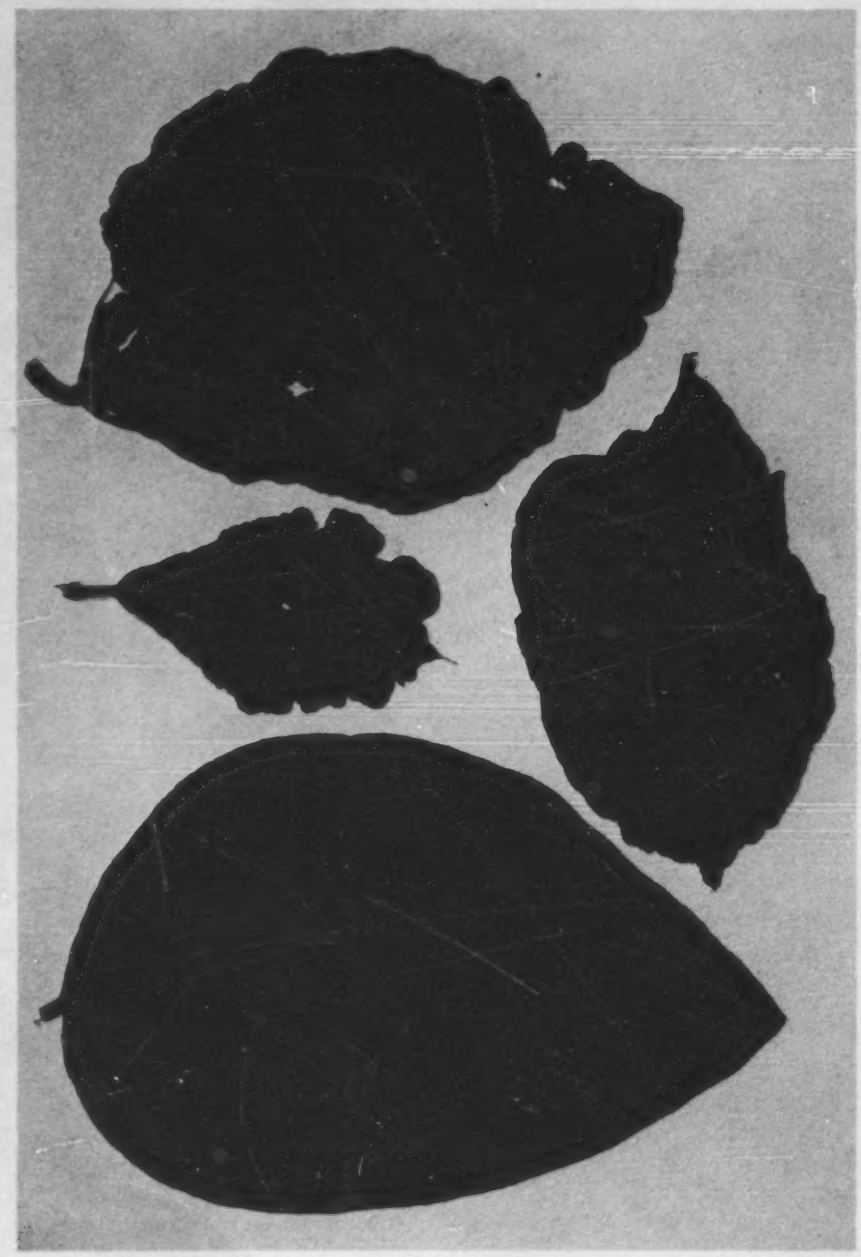
Powdery mildew is a common fungal disease with a large number of hosts, including cereal grains, cucurbits, clovers, apple, oak, willow, rose, lilac, grasses, and many annual flowers. Since the fungus flourishes under humid conditions, one of the best controls is to provide adequate air movement. Resistant varieties and fungicides are other commonly used controls for this disease. The superficial grayish-white mildew growth on the upper leaf surface is a diagnostic sign.

## ROOT-KNOT NEMATODE

Swellings on the roots of a plant indicating root-knot nematode infection.

Several species of root-knot nematode attack many different plants in Illinois. The nematode survives in soil overwinter. Nematode species are highly specific as to which plants they attack. By being familiar with the various species of the root-knot nematode, you can select crops that are immune. The root-knot nematode is spread by anything that moves infested soil — tillage equipment, plants, runoff water, etc. The various species of the root-knot nematode may be controlled by the use of resistant varieties, rotation, and soil fumigation. Unthrifty plant growth, wilting, and swellings on the roots are diagnostic symptoms.

## COMMON SOYBEAN MOSAIC



**The leaflets in the center and the leaflet at the top show the puckering and distortion characteristic of mosaic virus infection. A normal leaflet is shown at the bottom.**

Common soybean mosaic is a viral disease that appears to a limited extent throughout Illinois. The disease usually attacks individual plants within a field. The leaves of infected plants are distorted and narrower than normal, and their margins turn downward. They may have a yellowish cast, and usually show a light- and dark-green mottling, with blisterlike puckering along the veins. Common soybean mosaic is seedborne and transmitted by insects. It is not currently an important soybean disease, but infected plants should be rogued from a field where soybeans are grown for seed.

## WEEDS

A weed may be simply defined as "a plant out of place." Weeds compete with crop plants for moisture, nutrients, light, and growing space, and may cause lower yields in crops and lower quality in livestock.

Weeds may harbor disease and insect pests. Pollen and even the juices from some weeds are responsible for allergies in humans. Poison oak and poison ivy cause poisoning when they come in contact with the skin. Weeds may cause off-flavored milk in dairy cows, and can be poisonous to livestock when eaten. They also create problems along irrigation canals, drainage ditches, right-of-ways, industrial plant sites, and recreational areas.

### Annuals

Annual weeds complete their life cycle in less than one year. They may be either grasslike or broadleaved.

**Summer annuals** are plants that result from seeds that sprout in the spring. The plants grow, mature, set seed, and die before the winter of each year. Examples are velvetleaf, crabgrass, giant foxtail, cocklebur, and pigweed.

**Winter annuals** are plants that result from seeds that sprout in the fall. They overwinter as seedlings, mature, set seed, and die in the early summer. Examples are chickweed, cheat, annual bluegrass, and yellow-rooted henbit.

### Biennials

Biennial weeds have a two-year life cycle. The seed sprouts in the spring, and develops a heavy root system and compact cluster of leaves (vegetative growth) during the first summer. The weeds mature during the second summer, produce seed, and die before winter. Examples are bull thistle, burdock, and mullein.

### Perennials

Perennial weeds live more than two years, and may live almost indefinitely. During the winter, many lose their leaves and the stems of others may die back to the ground. Some perennials grow from seed; others produce tubers, bulbs, and rhizomes (belowground stems) or stolons (aboveground stems). Examples are field bindweed, johnsongrass, dandelion, wild garlic, and wild onion.

### Control

Several methods may be used in an effective weed control program, including the use of herbicides. To obtain the best results from an herbicide with the least possible harm to yourself and to the environment, you must understand the meanings of three terms: pre-emergence, preplant, and postemergence.

**Preemergence** refers to the use of an herbicide before the crop or weeds emerge, or after the crop emerges but before the weeds appear above the soil surface. **Preplant** refers to the use of an herbicide before the crop is planted. **Postemergence** refers to the use of an herbicide after the crops or weeds have emerged.

After you have determined when to apply an herbicide, you must decide *how* to apply it. The most commonly used methods of applying herbicides are (1) **broadcast** (uniform application over an entire specific area); (2) **foliar** (application to the leaves); (3) **soil application** (application to the soil); and (4) **soil incorporation** (using tillage equipment to mix the herbicide with the surface soil). Less commonly used methods are **band** (application to a strip or band parallel to a crop row); **basal** (application to the stems or trunks immediately above the groundline; **cracks or crevices** (application to cracks or crevices where weeds grow; **directed** (aiming the herbicide at a portion of a plant, animal, or structure); and **over-the-top** (application over the top of the growing crop).

A dealer or applicator should *never* make a recommendation to a customer until he is absolutely sure that he has correctly identified a particular weed. If there is any doubt, he should contact his local county extension adviser. If the adviser does not have the answer, an extension specialist should be consulted.

*(Some annual, biennial, and perennial weeds are shown on pages 61 and 62.)*

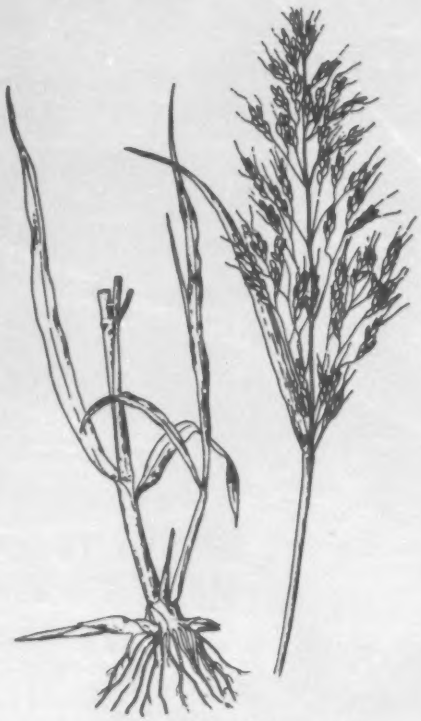
## WEEDS

Velvetleaf (Summer Annual)

Common Chickweed (Winter Annual)

Bull Thistle (Biennial)

**WEEDS**



Johnsongrass (Perennial)

Dandelion (Perennial)

Wild Garlic (Perennial)

Wild Onion (Perennial)

# CHAPTER NINE: PESTICIDE LAWS AND REGULATIONS

## FEDERAL ENVIRONMENTAL PESTICIDE CONTROL ACT

The Federal Environmental Pesticide Control Act (the Federal Insecticide, Fungicide, and Rodenticide Act of 1947, as amended in 1972) regulates the use of pesticides to protect humans and the environment. It does so by extending federal controls to the actual application of pesticides by the user, and by regulating both intrastate and interstate marketing of pesticide products.

All pesticides must be classified for either general or restricted use. A person must be certified to use a pesticide classified for restricted use. Competency for certification of commercial pesticide applicators and operators is determined by written examination, and competency of private pesticide operators by satisfactory completion of a training session or written examination.

To qualify for certification, pesticide applicators and operators are expected to (1) understand labels and labeling information and the classification of pesticides (general or restricted use); (2) know the causes of pesticide accidents and how to guard against injury; (3) realize the need for protective clothing and equipment; (4) recognize the symptoms of pesticide poisoning and be able to administer appropriate first-aid treatment; (5) know how to handle, store, and dispose of pesticides properly; (6) be aware of the influence of pesticides on the environment; (7) be able to identify common pests to be controlled; (8) be familiar with pesticide formulations and factors affecting their effectiveness; (9) know the common types of equipment and techniques of application; (10) know how to calibrate application equipment; and (11) understand laws and regulations. (Specific instructions for obtaining certification as a Commercial Pesticide Applicator or Operator or as a Private Pesticide Applicator are given in Appendix II.)

## ILLINOIS LAWS AND REGULATIONS

There are several laws regulating the use of pesticides in Illinois, and several state agencies are involved in their administration. These laws and their effects upon pesticide applicators and operators are discussed below.

### Custom or Public Application of Pesticides Act

The Custom or Public Application of Pesticides Act regulates pesticide application. This law is administered by the Illinois State Department of Agriculture. Any person violating any provision of this Act, or any regulation issued subsequent to this Act, is guilty of a misdemeanor, and upon conviction shall be fined not less than $100 nor more than $1,000 or imprisoned for not more than six months or both. In addition, the person's license may be modified or revoked.

#### *Commercial Pesticide Applicator for Hire License*

A Commercial Pesticide Applicator for Hire License is issued to a person who applies a pesticide for any purpose on property other than that owned, rented, or leased by himself or by his employer. Generally, a person who applies pesticides for profit is considered a commercial applicator. For certification, a person must be at least 16 years old, pass a written examination, pay a $25 fee, and post a $3,000 performance bond. The license is for one calendar year, and is renewable without examination at the discretion of the Director of Agriculture for five years.

#### *Commercial Pesticide Operator for Hire License*

A Commercial Pesticide Operator for Hire License is issued to a person who is employed and directly supervised by a person holding a Commercial Applicator for Hire License. A person holding a Commercial Pesticide Operator for Hire License is permitted to

recommend controls; operate application equipment; handle, mix, and apply pesticides; and dispose of excess pesticides and containers. For certification, a person must be at least 16 years old, pass a written examination, and pay a $10 annual fee. The license is for one calendar year, and is renewable without examination at the discretion of the Director of Agriculture for five years.

#### *Commercial Pesticide Applicator Not for Hire Licenses*

Commercial Pesticide Applicator Not for Hire Licenses are issued at no charge to persons who are applying restricted use pesticides on their own property or that of their employer but who are not public (governmental) employees. For certification, a person must be at least 16 years old, and must pass a written examination. The license is for one calendar year, and is renewable without examination for five years at the discretion of the Director of Agriculture. Examples of Commercial Pesticide Applicators Not for Hire include grain elevator managers and workers, private golf course superintendents, rural electric corporation fieldmen, railroad right-of-way maintenance personnel, and others.

#### *Public Pesticide Applicator and Operator Licenses*

Public Pesticide Applicator and Operator Licenses are issued at no charge to employees of governmental agencies. For certification, a person must be at least 16 years old, and must pass a written examination. The license is for one calendar year, and is renewable without examination for five years at the discretion of the Director of Agriculture. Examples of Public Pesticide Applicators and Operators include groundskeepers in public cemeteries and public golf courses, park district maintenance men, foresters (public land), mosquito abatement district personnel, county and township weed commissioners, groundskeepers of public establishments, and other public employers who apply pesticides in areas to which the public has access.

The Commercial and Public Applicator and Operator licensing categories covered by the Custom or Public Application of Pesticides Act are as follows:

1. **Field Crop Pest Control Applicator or Operator:** persons applying pesticides to corn, soybeans, small grains, forages, etc.

2. **Vegetable Crop Pest Control Applicator or Operator:** persons applying pesticides to vegetable crops.

3. **Fruit Crop Pest Control Applicator or Operator:** persons applying pesticides to fruit crops.

4. **Grain Facility Pest Control Applicator:** persons applying restricted use pesticides not for hire on their own property or employer's property for the control of pests in and around grain elevators or similar grain-handling facilities, conveyances, and transportation facilities. Governmental employees acting as public applicators or operators applying any pesticide (general and restricted use) in grain-handling facilities must be certified.

5. **Livestock Pest Control Applicator or Operator:** persons applying pesticides to livestock or livestock barns.

6. **Forest Pest Control Applicator or Operator:** persons applying pesticides to forested areas.

7. **Ornamental and Turf Pest Control Applicator or Operator:** persons applying pesticides to trees, shrubs, flowers, or turfgrass. Commercial applicators whose primary concern is maintenance of ornamental trees, including the application of pesticides to control pests, must also obtain a Tree Expert License from the Illinois Department of Registration and Education. (See Tree Expert Act.)

8. **Seed Treatment Pest Control Applicator or Operator:** persons applying pesticides to seeds of plants.

9. **Aquatic Weed Pest Control Applicator or Operator:** persons applying herbicides to aquatic areas.

10. **Right-of-Way Pest Control Applicator or Operator:** persons applying pesticides to rights-of-way, roadsides, noncrop areas, etc.

11. **Mosquito Pest Control Applicator or Operator:** persons applying insecticides to control mosquitoes.

12. **Demonstration and Research Pest Control Applicator:** persons demonstrating safe and effective use of restricted use pesticides to the public; and persons associated with research on pesticides, including determining the effectiveness of pesticides, residue problems, effect on nontarget organisms, etc. This category includes Cooperative Extension staff, industry representatives, researchers, vocational agriculture teachers, junior college teachers, and others. A licensee may directly supervise the application of restricted use pesticides by employees who are not certified. No license fee is required.

13. **Regulatory Pest Control Applicator:** government employees involved in the control of regulated pests with restricted use pesticides. A licensee may directly supervise the application of restricted use pesticides by employees who are not certified. No license fee is required.

A different examination is given for each license category. A person can obtain certification in several categories, depending upon his area of work. For license categories 1 to 3 and 5 to 11, there is no extra

charge for certification in more than one category. For information on training schools and study materials, contact your county extension adviser (telephone numbers for the county extension advisers in Illinois are listed in Appendix II).

Other requirements of the Illinois Custom or Public Applicator of Pesticides Act are as follows:

1. Certified Commercial and Private Pesticide Applicators must keep records for two years on the restricted use pesticides that they apply. These records must include the name of the pesticide used, amount applied per unit area, date of application, location of application, and the pest or pest controlled.
2. Before a restricted use pesticide can be purchased, a current, valid license or certification number must be recorded on the retail sales invoice slip.
3. Retail dealers must keep a record of all sales of restricted use pesticides for a minimum of two years.

If you have any questions concerning the legal requirements of this Act, contact the following:

Plant Pesticide Specialist Supervisors
Bureau of Plant and Apiary Protection
State Department of Agriculture
Emmerson Building, State Fairgrounds
Springfield, Illinois 62706
Phone: (217) 782-4101

#### *Private Pesticide Applicator License*

A Private Pesticide Applicator License will be issued to a person who uses or supervises the use of a restricted use pesticide on property owned, rented, or leased by himself or by his employer; or on no more than two neighbors' farms, as exchange labor, for the purpose of producing an agricultural commodity primarily intended for sale, consumption, propagation, or other use by humans or animals.

A person is not required to be certified as a Private Pesticide Applicator who uses a pesticide classified for *general use* on property owned, leased, or rented by himself or by his employer; or on no more than two neighbors' farms, as exchange labor, for the purpose of producing an agricultural commodity.

Persons in the following occupations can qualify for certification as Private Pesticide Applicators: agriculturists; canning company fieldmen; Christmas tree growers; farmers; floriculturists; foresters (private); fruit growers, nurserymen; orchardists; ranchers; seed producer fieldmen; seed treaters (who treat their own seed); vegetable growers; vineyardists, and home gardeners.

Groundskeepers in cemeteries, county or township weed commissioners, golf course maintenance men, foresters (public land), ground maintenance men of private and public establishments, park district maintenance men, and others who apply pesticides in areas where the public has access must obtain certification as Commercial or Public Pesticide Applicators or Operators.

A person can obtain certification as a Private Pesticide Applicator by satisfactorily completing a training session conducted by the Cooperative Extension Service, University of Illinois at Urbana-Champaign. The training schools are held at irregular intervals in each county by the county extension adviser. An official of the Illinois Department of Agriculture will be present at the training session to register those attending.

Each person seeking certification must fill out an application, complete the questions in a training evaluation form, and sign a statement saying that he or she understands the information presented at the training session and the legal responsibilities for the use of pesticides in accordance with label instructions. The answers given to questions in the training evaluation will not be graded, but the form must be completed and all questions answered. A person may take a written examination for certification as a Private Pesticide Applicator as an alternative to participating in a training session. The examination will be graded, and a passing grade must be achieved to obtain certification. The examination is "open book," and is available from the county extension adviser or the state or regional offices of the Illinois Department of Agriculture. There is no fee for certification as a Private Pesticide Applicator. Certification is valid for five calendar years.

### Structural Pest Control Act

The purposes of this Act are to protect, promote, and preserve the public health by establishing standards for selection, formulation, and application of pesticides; and to provide for licensing of commercial structural pest control and registration of noncommercial structural pest control locations, as well as the certification of pest control technicians involved with industrial, institutional, structural, and public-related pest control. The law is administered by the Illinois Department of Public Health.

Structural pest control can be defined as (1) the use of any method or device, or the application of any substance (including pesticides), to prevent, repel, mitigate, curb, control, or eradicate any pest in, on, or under a structure; or (2) solicitation to perform any of the above functions. Structural pest control includes fumigation of vaults, rail cars, trucks, ships, airplanes, and common carriers. Pests include insects, insect-related pests (spiders, ticks, mites), wood-infesting organisms, rats, mice, nuisance birds, and other ob-

noxious animals in, on, or under structures. A structure is defined as any building, its contents, any patio or terrace connected to the building, the land on which the structure is situated, and any land that might constitute a potential harborage for pests that could affect the building. Any person who violates this Act shall be guilty of a misdemeanor and subject to a fine of not less than $100.

#### *Commercial Structural Pest Control Location License*

A license must be obtained for each location from which a person conducts a structural pest control business for profit involving the storage, disposal, and application of pesticides to control structural pests. No examination is required. The license fee is $50, and the license is renewable each year. Each location must also be supervised by a certified technician when applying restricted use pesticides.

Each application for a license or license renewal must be accompanied by a certificate of insurance from an insurance company authorized to do business in Illinois. This certificate must provide public liability of $100,000 per person or $300,000 per occurrence, and at least $50,000 per occurrence of property damage resulting from structural pest control activities.

#### *Noncommercial Structural Pest Control Location Registration*

Registration must be obtained for each location from which a person conducts a structural pest control service, and stores, disposes, or applies restricted use pesticides not for profit but for use in his or her own business location or the business locations of his or her employer. No examination is required. The registration fee is $10 per year, and registration is renewable each year. This fee is waived for governmental agencies. Each location must also be supervised by a certified technician.

#### *Certified Technician License*

Persons storing, disposing, and applying restricted use pesticides to control structural pests must be certified or work under the supervision of a certified technician. For licensing, a person must fill out an application with the Illinois Department of Public Health giving evidence of the following qualifications:

1. That the applicant is 21 years of age.
2. That the applicant has worked for at least one year in structural pest control under the supervision of a certified technician.
3. That the applicant has paid the $25 fee required for application.
4. That the applicant has passed the examination required by the Act.

The license fee for a certified technician is $25 for a period of three years. The $25 fee submitted with the application for the examination covers the license fee, provided that the applicant passes the general core examination and at least one category specific examination. The applicant may also elect to take the examination in any other category without payment of additional fees. A certified technician may renew the license by furnishing evidence that he or she has attended one or more training seminars on structural pest control approved by the Illinois Department of Public Health during the three-year period, and by paying the required fee.

If a certified technician has not renewed the certificate for a period of more than three years, he or she must file an application for examination, pay the fee, and pass the examination for recertification.

A certified technician is required to keep records of applications of restricted use pesticides for a period of two years. The records must contain information on the kinds, amounts, uses, dates, and place of application of restricted used pesticides.

The Certified Technician Licensing categories covered by the Structural Pest Control Act are as follows:

1. **Insects, Rodents, and Other Pests:** persons using or supervising the use of restricted use pesticides but not fumigants for the prevention or control of insects, mites, ticks, rats, mice, squirrels, or other rodents and mammals in, under, or around structures, excluding termites, other wood-destroying pests, and birds.
2. **Termites and Other Wood-Destroying Organisms Pest Control:** persons using or supervising the use of restricted use pesticides but not fumigants for the prevention or control of termites, true powder post beetles, false powder post beetles, deathwatch beetles, carpenter ants, carpenter bees, and other wood-destroying pests in, under, or around structures.
3. **Bird Pest Control:** persons using or supervising the use of restricted use pesticides for the prevention or control of pest birds, including but not limited to sparrows, pigeons, and starlings in, on, or around structures.
4. **Fumigation Pest Control:** persons using or supervising the use of restricted use fumigants for the control of pests in but not limited to rail cars, trucks, ships, airplanes, docks, and warehouses, and involving general, spot, tarpaulin, chamber, vehicle, and in-transit fumigation.
5. **Food Manufacturing, Food Processing, and Food Storage Facilities Pest Control:** persons not for hire using or supervising the use of restricted use pesticides in a noncommercial structural pest control location (see noncommercial structural pest control lo-

cation registration), for the prevention or control of insects, rodents, and other pests associated with the manufacturing, processing, packaging, or holding of food or feed products for consumption by man or animals where such products are not served or offered for sale directly to the ultimate consumer. This license does not permit the certified technician not for hire to use or supervise the use of restricted use pesticides for the control of termites and other wood-destroying organisms, for bird control or fumigation pest control in the noncommercial structural pest control location. The applicant must also pass the examination in categories 2, 3, and 4 to engage in these activities.

6. **Institutional and Multi-Unit Residential Housing Pest Control:** persons not for hire using or supervising the use of restricted use pesticides in a noncommercial structural pest control location (see Noncommercial Structural Pest Control Location Registration above) for the prevention or control of insects, rodents, and other pests in, on, or around state institutions, nursing homes, hospitals, public housing facilities, and similar installations. This license does not permit the certified technician not for hire to use or supervise the use of restricted use pesticides for the control of termites and other wood-destroying organisms, bird control, or fumigation pest control in the noncommercial structural pest control locations. The applicant must also pass the examination in categories 2, 3, and 4 to engage in these activities.

7. **Public Health Pest Control:** governmental employees (federal, state, county, and municipal) using or supervising the use of restricted use pesticides for the prevention or control of pests of public health importance other than mosquitoes.

If you wish further information about these license categories, contact the following office:

Entomologist
State Department of Public Health
535 Jefferson Street West II
Springfield, Illinois 62706
Phone: (217) 782-4674

### The Illinois Tree Expert Act

The Illinois Tree Expert Act licenses persons who for profit diagnose, recommend, or supervise the treatment of trees by feeding, fertilizing, pruning, trimming or bracing, or who attempt to protect trees from damage by insects or disease by spraying or other methods. A tree is generally defined as any plant that a small boy can climb. This Act is administered by the State Department of Registration and Education. For certification, a person must pass a written examination. The license is for one calendar year, and is renewable without examination. An original license is $35, and a renewal license is $10. A person may work under the direction and personal supervision of a licensed Tree Expert without being certified as a Tree Expert. A licensed Tree Expert must also be certified as an Ornamental and Turf Pest Control Applicator in order to use a restricted use pesticide. For further information about this Act, contact the following office:

Tree Expert Examining Board
State Department of Registration and Education
628 East Adams Street
Springfield, Illinois 62706
Phone: (217) 782-4643

### Pesticides Control Act

The Pesticides Control Act designates the State Departments of Agriculture and Public Health as responsible for controlling the labeling, sale, use, and application of pesticides to prevent the contamination of water and the environment.

The State Department of Agriculture is responsible for the control of pesticides used in the production, protection, care, storage, or transportation of agricultural commodities.

The State Department of Public Health is responsible for the regulation of pesticides used to control pests of importance to public health, such as household pests, disease-carrying insects and related animals, and rodents, birds, and mammals. All rules and regulations proposed by these agencies must be submitted to and approved by the Interagency Committee on Pesticides before they become effective.

### Interagency Committee on Pesticides Act

The Interagency Committee on Pesticides controls and regulates pesticide use in Illinois. It is the legislative arm of the state government in this respect. The State Department of Agriculture is empowered to receive grant-in-aid funds, and the Interagency Committee disperses these funds. The committee is composed of the following: Director, State Department of Agriculture (Chairman); Director, State Department of Public Health; Director, State Department of Transportation; Director, State Department of Conservation; Director, State Environmental Protection Agency; Dean of the College of Agriculture, University of Illinois at Urbana-Champaign; and Chief of the Illinois Natural History Survey.

### Illinois Economic Poison Law

*The Illinois Economic Poison Law* requires the registration of pesticides that are distributed, transported, sold, or offered for sale in the state. To register a pesticide, a person must supply his name and address, the name of the pesticide, a copy of the label and the U.S. EPA registration number, and pay a $5 annual fee. The $5 fee is required for each pesticide registered. In general, only those pesticides already registered by the U.S. EPA will be accepted for registration by the State of Illinois. However, state registration of pesticides for special local needs can be obtained if approved by the Illinois Department of Agriculture.

### 2,4-D and Related Herbicide Act

The 2,4-D and Related Herbicide Act provides the opportunity for a county board of ten or more owners or operators of land who are commercial producers of fruits or vegetables to petition the State Department of Agriculture to restrict or prohibit the use of 2,4-D or related herbicides in their area. It must be shown that an herbicide or herbicides were harmful to the production of fruits and vegetables in prior years, and that this production is one of the principal sources of agricultural income within the area. The Director of the State Department of Agriculture may issue an order to prohibit or restrict the use of certain herbicides within the affected area for a period of up to two years, if he finds that the evidence justifies such action.

### Water Pollution Regulations: Illinois Pollution Control Board Rule 203(h)

One of the responsibilities of the Illinois Pollution Control Board is to restore, maintain, and enhance the purity of waters in Illinois. The primary pesticides having U.S. EPA label clearance on aquatic sites are certain herbicides to kill weeds, certain insecticides to kill mosquitoes, and piscicides to kill undesirable fish. This Board has adopted the following rules and regulations governing applications of pesticides to aquatic sites:

1. A person applying a U.S. EPA registered pesticide to an aquatic site shall be properly certified under the provisions of the 1972 amended Federal Insecticide, Fungicide, and Rodenticide Act.

2. The application shall be made in strict accordance with label directions and applicable laws, regulations, and guidelines of the appropriate local, state, and federal authorities.

3. No pesticide shall be applied to waters affecting public or food-processing water supplies unless a permit to apply the pesticide has been obtained from the Illinois Environmental Protection Agency.

4. No piscicide shall be applied to aquatic sites without the approval of the Illinois Department of Conservation.

### Toxic Sustances: Illinois Pollution Control Board Rules and Regulations

The storage and transport of toxic substances, including pesticides, are regulated to minimize the chance of accidental, negligent, or intentional discharge of other substances into the environment.

Pesticides are exempt from these regulations if they are contained in U.S. Department of Transportation-approved specification containers, and the pesticide in each container does not exceed the maximum quantity in one package permitted for express rail car. Otherwise, any person who stores or transports a pesticide listed on the Illinois Regulated Chemical List must register with the Illinois Environmental Protection Agency and provide the required information for that pesticide.

## FEDERAL AND ILLINOIS LAWS PROTECTING BIRDS

Under federal law, all birds are protected except the starlings, feral (wild) pigeons, and English sparrows. Cowbirds, blackbirds, and grackles may be destroyed only when they are causing or about to cause damage to agricultural crops, ornamentals, or shade trees.

Illinois conservation laws protect all birds except the English sparrow, European starling, and domestic pigeon. Mammals except rats and mice are also protected.

The Illinois Department of Conservation (State Office Building, Room 602, Springfield, Illinois 62706) can grant authority to owners or tenants to protect their property from any wild birds or wild mammals except game birds or migratory game birds.

# CHAPTER TEN:
# GLOSSARY OF COMMON PESTICIDE TERMS

**ABSORPTION.** The entrance of a pesticide into the body through the skin. Also refers to the entrance of a pesticide into a plant or microorganism.

**ACARICIDE.** A pesticide used to kill mites (an insect relative). Also known as a miticide.

**ACTIVE INGREDIENT.** The amount of actual pesticide in the formulation.

**ACUTE TOXICITY.** A single or limited exposure to a pesticide that may result in injury or death.

**ADSORPTION.** The binding of a pesticide to the outside surface of small soil particles or to plant parts.

**AEROSOL.** A fine mist produced when a pesticide that is dissolved in a liquid is released as a gas into the air from a pressurized container.

**ANNUAL WEED.** A weed that lives one year and is perpetuated only by seed.

**ANTIDOTE.** A remedy used to counteract the effects of a poison.

**APPLICATION RATE.** The amount of pesticide formulation applied to a given area.

**ATTRACTANT.** A substance that attracts destructive animals. Generally used with a killing agent or trap.

**AVICIDE.** A pesticide used to prevent, destroy, repel, mitigate, or attract birds.

**BAND APPLICATION.** Application made as a band over or parallel to a crop row.

**BASAL APPLICATION.** Application to the stems or trunks of plants at and immediately above the groundline.

**BIENNIAL WEED.** A weed that lives for more than one year but not more than two years.

**BIOLOGICAL CONTROL.** Control of pests by means of living organisms such as predators, parasites, and disease-producing organisms.

**BROADCAST APPLICATION.** Application made uniformly over an entire field.

**CARBAMATE.** A salt or ester of carbamic acid; a nerve poison. Examples are carbaryl, carbofuran, and propoxur.

**CARRIER.** Inert material such as dust, clay, oil, water, and air that is mixed with the pesticide and provides for its more uniform dispersal.

**CHEMOSTERILANT.** A chemical used to sterilize insects.

**CHLORINATED HYDROCARBON INSECTICIDE.** A synthetic pesticide that contains hydrogen, carbon, oxygen, and chlorine. Chlorinated hydrocarbon insecticides are persistent insecticides that kill insects mainly by contact action. They are insoluble in water, and are decomposed by alkaline materials and high temperatures. Examples are DDT, aldrin, chlordane, dieldrin, heptachlor, lindane, toxaphene, and methoxychlor.

**CHRONIC TOXICITY.** A prolonged exposure to a pesticide that may result in injury or death.

**COMMERCIAL PESTICIDE APPLICATOR.** A person who applies pesticides (for hire, not for hire, or public) to land or commodities as specified in the 12 commercial categories (page 64). For a detailed discussion of Commercial Pesticide Applicators, see Chapter Nine.

**COMPATIBLE CHEMICALS.** Chemicals that can be mixed together without decreasing their effectiveness against the intended pests.

**CONCENTRATION.** The amount of actual pesticide or active ingredient contained in a formulation or mixture. Expressed as percent, pounds per gallon, etc.

**CONTACT PESTICIDE.** A pesticide that kills on contact.

**CROP TOLERANCE.** The ability of a crop to be treated with a pesticide but not injured.

**DEFOLIANT.** A pesticide that causes leaves to drop from a plant prematurely.

**DESICCANT.** A pesticide that cuts through or penetrates the skin of insects or the leaf surfaces of plants and causes tissues to dry out.

**DILUENT.** Any material used to dilute a pesticide to the desired concentration.

**DIRECTED APPLICATION.** Application to a specific kind of plant or parts of a plant.

**DRIFT.** The movement of material by air outside the intended target area during or shortly after application.

**DUST.** A formulation usually consisting of the active pesticide ingredient mixed with an inert material such as a talc, clay, powdered nut hulls, volcanic ash, and similar materials.

**ECONOMIC THRESHOLD.** The number of insects per plant or the amount of damage to a plant before pesticide protection is financially justifiable.

**EMULSIFIABLE CONCENTRATE.** A liquid formulation containing an emulsifier and a pesticide dissolved in a solvent. Designed to be mixed with water to the desired strength before being used.

**EMULSION.** The suspension of one liquid as minute globules in another liquid. For example, oil and water.

**ENVIRONMENT.** Soil, water, air, plants, animals, and humans make up the environment.

**FLOWABLE.** A finely ground wettable powder formulation that is sold as a thick suspension in a liquid. Flowables require only moderate agitation and seldom clog spray nozzles.

**FORMULATION.** The form in which a pesticide is offered for sale to the user (as emulsifiable concentrate, wettable powder, granule, dust, oil solution, etc.). Includes both the active and inert ingredients.

**FUMIGANT.** A pesticide that as a gas kills destructive microorganisms, animals, and plants.

**FUNGICIDE.** A pesticide used to prevent, destroy, repel, or mitigate fungal infection.

**FUNGISTAT.** A pesticide that inhibits the growth of fungi but does not kill them.

**FUNGUS.** A small, many-celled, nongreen plant. Some fungi attack other plants and cause plant diseases such as rusts, smuts, mildews, wilts, and leaf spots.

**GRANULES.** A formulation in which the pesticide is attached to particles of an inert carrier such as clay or ground corncobs. Currently used granules range in size from 15 to 40 mesh.

**GROWTH REGULATOR.** A hormonal chemical capable of changing the growth of a plant or animal.

**HAZARD.** The likelihood that an injury will result from the use of a pesticide. Includes both toxicity and exposure.

**HERBICIDE.** A pesticide used to prevent, destroy, or mitigate plants that grow where they are not wanted.

**HOST.** Any plant or animal that is invaded by a parasite, and from which the parasite obtains its food.

**INERT INGREDIENTS.** Ingredients of a pesticide formulation that are not active, such as water, sugar, dust, wetting and spreading agents, emulsifiers, propellents, etc.

**INSECT.** A term used to describe numerous small invertebrate (no backbone) animals, such as true insects, spiders, mites, ticks, centipedes, and millipedes. In the adult stage, true insects usually have six walking legs, wings, and three body divisions.

**INSECTICIDE.** A pesticide used to prevent, destroy, repel, mitigate, or attract insects and their relatives.

**LABEL.** A printed statement affixed to the pesticide container by the manufacturer listing the contents, directions for use, and precautions. A pesticide label must be approved and registered by the U.S. Environmental Protection Agency and the State Department of Agriculture.

**LARVA.** The immature or worm stage (caterpillar, maggot, grub) of an insect that passes through four stages (egg, larva, pupa, adult) in its development.

**LARVACIDE.** An insecticide used to kill larvae of insects.

**$LC_{50}$.** Amount of pesticide in water or air required to kill 50 percent of a test animal population in a 24-hour period. Usually expressed in parts per million (ppm) or micrograms per liter.

**$LD_{50}$.** Amount of pesticide taken orally or dermally required to kill (lethal dose) 50 percent of a test animal population. Usually expressed in milligrams of pesticide per kilogram of body weight of the test animal.

**MG/KG.** The amount of pesticide in milligrams per kilogram of animal body weight used to determine the toxicity of a pesticide (1,000,000 mg = 1 kg = 2.2 pounds).

**MUTAGENIC.** A substance that causes genetic or somatic changes in subsequent generations.

**NEMATICIDE.** A pesticide used to prevent, repel, destroy, or mitigate nematodes.

**NEMATODES.** Generally microscopic, unsegmented roundworms that usually live free in moist soil, water, or decaying matter, or as parasites of plants and animals.

**NONTARGET ORGANISM.** A plant or animal other than the one against which the pesticide is applied.

**NOZZLE.** A device for metering and dispersing a spray solution.

**NYMPH.** The immature stage (resembling an adult) of an insect that passes through three stages (egg, nymph, and adult) in its development.

**ONCOGENIC.** A substance that causes tumor formations.

**ORGANIC PHOSPHORUS INSECTICIDE.** A synthetic compound derived from phosphoric acid. Organic phosphorus insecticides are primarily contact killers with relatively short-lived effects. They are decomposed by water, pH extremes, high temperature, and microorganisms. Examples are malathion, parathion, diazinon, phorate, TEPP, dimethoate, and fenthion.

**ORIFICE.** An opening in a nozzle tip, duster, or granular applicator through which the spray, dust, or granules flow.

**OVICIDE.** A pesticide used to kill the eggs of insects.

**PARASITIC INSECT.** An insect that lives in or on the body of another insect.

**PATHOGEN.** An organism or agent capable of causing disease.

**PERENNIAL WEED.** A weed that lives for two or more years.

**PEST.** Any insect, mite, rodent, nematode, fungus, weed, or other plant or animal (except those microorganisms in or on living humans or animals) that is injurious to the health of humans, animals, or plants or to the environment.

**PESTICIDE.** A chemical or mixture of chemicals used to destroy, prevent, mitigate, repel, or attract any animal, plant, or plant disease considered a pest. Examples are insecticides, herbicides, fungicides, rodenticides, nematicides, disinfectants, bactericides, chemical defoliants, desiccants, and plant regulators.

**PHYTOTOXIC.** A pesticide that is injurious or poisonous to plants.

**PLANT REGULATOR.** A pesticide that causes fruit thinning, fruit setting, increased flowering, extended flowering, fruit ripening stimulation, etc.

**POISONOUS BAIT.** A chemical that causes a deleterious effect when absorbed or eaten by a living organism.

**POSTEMERGENCE.** Application of an herbicide after emergence of the crop or weed.

**PPM (PARTS PER MILLION).** One pound in 500 tons; one ounce in 8,000 gallons; one inch in about 16 miles.

**PREDATORY OR PREDACEOUS INSECT.** An insect that feeds on other insects.

**PREEMERGENCE.** Application of an herbicide before emergence of the crop.

**PREPLANT.** Application of an herbicide before the crop is planted.

**PROPELLENT.** A gas or liquid used in a pressurized pesticide product to expel the contents.

**PROTECTANT.** A pesticide used to prevent infection by an organism.

**PRIVATE PESTICIDE APPLICATOR.** A person certified to use or supervise the use of a restricted use pesticide on property owned, leased, or rented by himself or by his employer on no more than two neighbors' farms, as exchange labor, for the purpose of producing an agricultural commodity primarily intended for sale, consumption, propagation, or other use by humans or animals.

**PUPA.** The resting stage of an insect that passes through four stages (egg, larva, pupa, and adult) in its development.

**REENTRY TIME.** The waiting period following a pesticide application for workers to enter a field without wearing protective clothing.

**REPELLENT.** A pesticide used to repel rather than kill an animal pest.

**RESIDUAL.** The property of a pesticide for persisting after application in amounts sufficient to kill pests for several days to several weeks or even longer.

**RESISTANT SPECIES.** Pests that survive relatively high rates of pesticide application.

**RESIDUE.** The amount of pesticide present following application.

**RODENT.** A mammal that feeds mostly on plants and grains, although some rodents occasionally eat meat. Examples are rats, mice, and squirrels.

**RODENTICIDE.** A pesticide used to prevent, destroy, repel, or mitigate rodents.

**RUNOFF.** Pesticide material that is carried away from an area by the flow of surface water. Also used to describe the rate of application to a surface — "spray to runoff."

**SELECTIVITY.** The ability of a pesticide to kill some pests but not others.

**SELECTIVE HERBICIDE.** An herbicide that is more toxic to certain species of plants than to others.

**SOIL STERILANT.** A pesticide that completely prevents the growth of plants and microorganisms.

**SOIL STERILIZATION.** Treating soil by heat or chemicals to kill living organisms.

**SOLUBILITY.** The maximum amount of a liquid or solid that will dissolve in a liquid.

**SOLUBLE POWDER.** A powder formulation that dissolves and forms a solution in water.

**SOLUTION.** A mixture in which a pesticide is dissolved in a liquid, usually an oil solvent. The pesticide is evenly dispersed as individual molecules among the molecules of liquid.

**SPOT TREATMENT.** Application to a restricted or small area.

**SURFACTANT.** A material that reduces surface tension between two unlike materials such as oil and water. A spreader or wetting agent used to increase coverage of the surface being sprayed.

**SUSPENSION.** A mixture in which the pesticide in a solid form (tiny particles) is suspended in water.

**SUSCEPTIBLE SPECIES.** Pests readily killed by relatively low rates of pesticide application.

**SYMPTOM.** The reaction of a plant or animal to a pest's activities.

**SYNERGIST.** A chemical that, when mixed with a pesticide, increases its toxicity. The synergist may or may not have pesticidal properties of its own.

**SYSTEMIC PESTICIDE.** A pesticide that is absorbed by treated plants or animals and translocated via their circulatory systems to most tissues.

**TENACITY.** The tendency of a pesticide deposit to resist removal by weathering.

**TERATOGENIC.** A substance that causes abnormalities in an animal embryo or fetus.

**TOLERANCE.** The amount of pesticide deemed safe and permitted by law on an agricultural product.

**TOPICAL APPLICATION.** Application to the top or to the upper surface of the plant.

**TOXICITY.** The capacity of a pesticide to cause harm to a living organism.

**TOXIN.** A poison produced by a plant or animal.

**TRANSLOCATED PESTICIDE.** See Systemic Pesticide.

**VOLATILITY.** The rate of evaporation of a pesticide.

**WEED.** Any plant growing in a place where it is not wanted. A weed may be a grass or grasslike plant (such as crab grass or nutsedge) or a broadleaf plant (such as morning glory or a tree).

**WETTABLE POWDER.** A powder formulation containing a wetting agent that causes the powder to form a suspension in water.

# APPENDIX I:
# POISON TREATMENT CENTERS IN ILLINOIS

**The names and telephone numbers of poison treatment centers in Illinois are listed below. This list was revised August, 1976. Only licensed physicians should contact these centers.**

**ALTON**
Alton Memorial Hospital
Memorial Drive
(618) 462-8851

**AURORA**
Copley Memorial Hospital
Lincoln and Weston Avenues
(312) 897-6021, Ext. 725
896-3911 direct line

**BELLEVILLE**
Memorial Hospital
4501 N. Park Drive
(618) 233-7750, Ext. 250

**BELVIDERE**
Highland Hospital
1625 State Street
(815) 547-5441, Ext. 367

**BERWYN**
MacNeal Memorial Hospital
3249 S. Oak Park Avenue
(312) 797-3159

**BLOOMINGTON**
Mennonite Hospital
807 N. Main Street
(309) 828-5241, Ext. 395

St. Joseph's Hospital
2200 E. Washington
(309) 662-3311, Ext. 356

**CAIRO**
Padco Community Hospital
2020 Cedar Street
(618) 734-2400, Ext. 42

**CANTON**
Graham Hospital Association
210 W. Walnut Street
(309) 647-5240, Ext. 240

**CARBONDALE**
Doctors Memorial Hospital
404 W. Main Street
(618) 549-0721, Ext. 341

**CARTHAGE**
Memorial Hospital
South Adams Street
(217) 357-3131, Ext. 84 or 85

**CENTRALIA**
St. Mary's Hospital
400 N. Pleasant Avenue
(618) 532-6731, Ext. 716

**CHAMPAIGN**
Burnham City Hospital
407 S. Fourth Street
(217) 337-2533

**CHANUTE AIR FORCE BASE**
United States Air Force Hospital
(217) 495-3133
Limited to treatment of military personnel and families except for designated civilian emergencies

**CHESTER**
Memorial Hospital
1900 State Street
(618) 826-4581

**CHICAGO**
Children's Memorial Hospital
2300 Children's Plaza
(312) 649-4161

Cook County Children's Hospital
700 S. Wood Street
(312) 633-6542, 633-6543, or 633-6544

Mercy Hospital and Medical Center
Stevenson Expressway and
Martin Luther King Drive
(312) 567-2017

Michael Reese Hospital Medical Center
29th and Ellis Avenue
(312) 791-2810

Mt. Sinai Hospital
California at 15th Street
(312) 542-2030

Resurrection Hospital
7435 W. Talcott Avenue
(312) 774-8000, Ext. 401

St. Mary of Nazareth Hospital Center
2233 W. Division Street
(312) 770-2419

South Chicago Community Hospital
2320 E. Ninety Third Street
(312) 978-2000

University of Illinois Hospitals
840 S. Wood Street
(312) 996-6885 or 996-6886

Wyler Children's Hospital
950 E. 59th Street
(312) 947-6231

**DANVILLE**
Lake View Medical Center
812 N. Logan Avenue
(217) 443-5221

St. Elizabeth Hospital
600 Sager Avenue
(217) 442-6300, Ext. 647, 674, or 736

**DECATUR**
Decatur Memorial Hospital
2300 N. Edward Street
(217) 877-8121, Ext. 676

St. Mary's Hospital
1800 E. Lakeshore Drive
(217) 429-2966, Ext. 731, 732, 733, or 742

**DE KALB**
Kishwaukee Community Hospital
Route 23 and Bethany Road
P.O. Box 707
(815) 756-1521, Ext. 491

**DES PLAINES**
Holy Family Hospital
100 N. River Road
(312) 297-1800, Ext. 1000

**EAST ST. LOUIS**
Christian Welfare Hospital
1509 Martin Luther King Drive
(618) 874-7076, Ext. 216 or 232

St. Mary's Hospital
129 N. Eighth Street
(618) 274-1900, Ext. 204 or 268

EFFINGHAM

St. Anthony Memorial Hospital
503 N. Maple Street
(217) 342-2121, Ext. 211 or 212

ELGIN

St. Joseph's Hospital
77 Airlite Street
(312) 695-3200, Ext. 348

Sherman Hospital
934 Center Street
(312) 742-9800, Ext. 681

ELMHURST

Memorial Hospital of DuPage County
209 Avon Road
(312) 833-1400, Ext. 550

EVANSTON

Evanston Hospital
2650 Ridge Avenue
(312) 492-6460

St. Francis Hospital
355 Ridge Avenue
(312) 492-2440

EVERGREEN PARK

Little Company of Mary Hospital
2800 W. 95th Street
(312) 445-6000, Ext. 221

FAIRBURY

Fairbury Hospital
519 S. Fifth Street
(815) 692-2346, Ext. 248

FREEPORT

Freeport Memorial Hospital
420 S. Harlem Avenue
(815) 235-4131, Ext. 228

GALESBURG

Galesburg Cottage Hospital
695 N. Kellogg
(309) 343-8131, Ext. 336, 356, or 386

St. Mary's Hospital
3333 N. Seminary
(309) 343-3161, Ext. 255 or 256

GRANITE CITY

St. Elizabeth Hospital
2100 Madison Avenue
(618) 876-2020, Ext. 421

HARVEY

Ingalls Memorial Hospital
One Ingalls Drive
(312) 333-2300, Ext. 5295

HIGHLAND

St. Joseph's Hospital
1515 Main Street
(618) 654-2171, Ext. 297 or 298

HIGHLAND PARK

Highland Park Hospital
718 Glenview Avenue
(312) 432-8000

HINSDALE

Hinsdale Sanitarium and Hospital
120 N. Oak Street
(312) 887-2600

HOOPESTON

Hoopeston Community Memorial Hospital
701 E. Orange Street
(217) 283-5531

JACKSONVILLE

Passavant Memorial Area Hospital
1600 W. Walnut
(217) 245-9541

JOLIET

St. Joseph Hospital
333 N. Madison Street
(815) 725-7133, Ext. 571, 572, 573, or 574

Silver Cross Hospital
1200 Maple Road
(815) 729-7563 or 729-7565

KANKAKEE

Riverside Hospital
350 N. Wall Street
(815) 933-1671, Ext. 606

St. Mary's Hospital
500 West Court
(815) 939-2100

KEWANEE

Kewanee Public Hospital
719 Elliott Street
(309) 853-3361, Ext. 219

LAKE FOREST

Lake Forest Hospital
660 Westmoreland
(312) 234-5600, Ext. 683, 684, or 685

LA SALLE

St. Mary Hospital
1015 O'Conor Avenue
(815) 223-0607, Ext. 14

LINCOLN

Abraham Lincoln Memorial Hospital
315 Eighth Street
(217) 732-2161, Ext. 346

MACOMB

McDonough District Hospital
525 E. Grant Street
(309) 833-4101, Ext. 433

MATTOON

Memorial Hospital
2101 Champaign Avenue
(217) 234-8881, Ext. 29

MAYWOOD

Loyola University Hospital
2160 First Avenue
(312) 531-3000

McHENRY

McHenry Hospital
3516 W. Waukegan Road
(815) 385-2200, Ext. 602

MELROSE PARK

Westlake Community Hospital
1225 Superior Street
(312) 681-3000, Ext. 226 or 239

MENDOTA

Mendota Community Hospital
Route 51 and Memorial Drive
(815) 539-7461, Ext. 225

MOLINE

Moline Public Hospital
635 Tenth Avenue
(309) 762-3651, Ext. 233

MONMOUTH

Community Memorial Hospital
1000 W. Harlem Avenue
(309) 734-3141, Ext. 224

MOUNT CARMEL

Wabash General Hospital
1418 College Drive
(618) 263-3112, Ext. 211

MOUNT VERNON

Good Samaritan Hospital
605 N. Twelfth Street
(618) 242-4600, Ext. 521

NAPERVILLE

Edward Hospital
S. Washington Street
(312) 355-0450, Ext. 326

NORMAL

Brokaw Hospital
Virginia at Franklin Avenue
(309) 829-7685, Ext. 274

OAK LAWN

Christ Community Hospital
4440 W. 95th Street
(312) 425-8000, Ext. 382

OAK PARK

West Suburban Hospital
518 N. Austin Boulevard
(312) 383-6200

OLNEY

Richland Memorial Hospital
800 Locust Street
(618) 395-2131, Ext. 226 or 228

OTTAWA

Community Hospital of Ottawa
1100 E. Norris Drive
(815) 433-3100, Ext. 227

**PARK RIDGE**
Lutheran General Hospital
1775 Dempster Street
(312) 696-5151

**PEKIN**
Pekin Memorial Hospital
14th and Court Streets
(309) 347-1151, Ext. 430

**PEORIA**
Methodist Hospital of Central Illinois
221 N.E. Glen Oak
(309) 672-5500

Proctor Community Hospital
5409 N. Knoxville Avenue
(309) 691-4702, Ext. 791

St. Francis Hospital Medical Center
530 N.E. Glen Oak Avenue
(309) 672-2109, 672-2110, or 672-2111

**PERU**
People's Hospital
925 West Street
(815) 223-3300, Ext. 253

**PITTSFIELD**
Illini Community Hospital
640 W. Washington Street
(217) 285-2113, Ext. 238

**PRINCETON**
Perry Memorial Hospital
530 Park Avenue East
(815) 875-2811, Ext. 311

**QUINCY**
Blessing Hospital
1005 Broadway
(217) 223-5811, Ext. 255

St. Mary Hospital
1415 Vermont Street
(217) 223-1200, Ext. 260

**ROCKFORD**
Rockford Memorial Hospital
2400 N. Rockton Avenue
(815) 968-6861, Ext. 441

St. Anthony Hospital
5666 E. State Street
(815) 226-2041

Swedish-American Hospital
1316 Charles Street
(815) 968-6898, Ext. 534

**ROCK ISLAND**
Rock Island Franciscan Hospital
2701 Seventeenth Street
(309) 793-1000, Ext. 2106

**ST. CHARLES**
Delnor Hospital
975 N. Fifth Avenue
(312) 584-3300, Ext. 229

**SPRING VALLEY**
St. Margaret's Hospital
600 E. First Street
(815) 663-2611, Ext. 464 or 466

**SPRINGFIELD**
Memorial Medical Center
First and Miller Streets
(217) 528-2041, Ext. 460

St. John's Hospital
800 E. Carpenter
(217) 544-6464, Ext. 210

**STREATOR**
St. Mary's Hospital
111 E. Spring Street
(815) 673-2311, Ext. 221

**URBANA**
Carle Foundation Hospital
611 W. Park Street
(217) 337-3313

Mercy Hospital
1400 W. Park Avenue
(217) 337-2131

**WAUKEGAN**
St. Therese Hospital
2615 W. Washington Street
(312) 688-6470

Victory Memorial Hospital
1324 N. Sheridan Road
(312) 688-4181

**WINFIELD**
Central DuPage Hospital
0 North, 025 Winfield Road
(312) 653-6900, Ext. 556

**WOODSTOCK**
Memorial Hospital
for McHenry County
527 W. South Street
(815) 338-2500, Ext. 215 or 232

**ZION**
Zion-Benton Hospital
Shiloh Boulevard
(312) 872-4561, Ext. 239 or 240

# APPENDIX II: INSTRUCTIONS FOR OBTAINING CERTIFICATION

## COMMERCIAL APPLICATOR OR OPERATOR

Persons wishing to become licensed as Commercial Pesticide Applicators or Operators are required to pass a written examination and pay a license fee. Applicators must also post a bond.

Examinations may be taken at the State Department of Agriculture, Emmerson Building, State Fairgrounds, Springfield, Illinois 62706 (Telephone: 217-782-4101); or at the State Department of Agriculture, 999 North Main Street, Room 200, Glen Ellyn, Illinois 60137 (Telephone: 312-469-8621). The offices at both of these locations are open from 8:00 a.m. to 5:00 p.m., Monday through Friday.

Examinations are also given at 10 Urban Pesticide Dealer and Applicator Clinics and 10 Agricultural Pesticide Dealer and Applicator Clinics held at various locations in Illinois each year. These clinics are conducted jointly by the Illinois Cooperative Extension Service and the Illinois Natural History Survey.

The Urban and Agricultural Clinics provide instruction on the material contained in this *Study Guide*, as well as current recommendations for controlling pests and the latest research results. The Urban Clinics are designed for commercial applicators who apply pesticides on ornamentals, turf, rights-of-way, and forested areas, and for aquatic weed control. The Agricultural Clinics are designed for commercial applicators who apply pesticides to field crops, and for aquatic weed control.

Representatives of the State Department of Agriculture are in attendance at all of these clinics to administer examinations to those who wish to become licensed in a particular category. Although a Commercial Pesticide Applicator is not required to attend these clinics, he must pass a written examination before he can obtain a license.

## PRIVATE PESTICIDE APPLICATOR

A person can become certified as a Private Pesticide Applicator by satisfactorily completing a special training session conducted by the Cooperative Extension Service, University of Illinois, and monitored by the Illinois Department of Agriculture; or by passing a written examination issued by the Illinois Department of Agriculture. You may obtain information concerning where and when these training sessions will be held in your area or a copy of the written examination by contacting your county extension adviser. The telephone numbers for the county extension advisers in Illinois are listed below.

| | |
|---|---|
| Adams County | 217-223-8380 |
| Bond County | 618-664-3665 |
| Boone County | 815-544-3710 |
| Brown County | 217-773-3013 |
| Bureau County | 815-875-2878 |
| Calhoun County | 618-576-2419 |
| Carroll County | 815-244-9444 |
| Cass County | 217-452-7255 |
| Champaign County | 217-352-3312 |
| Christian County | 217-824-4897 |
| Clark County | 217-826-5422 |
| Clay County | 618-665-4513 |
| Clinton County | 618-526-4551 |
| Coles County | 217-345-7034 |
| Cook County | 312-532-4369 |
| Crawford County | 618-546-1549 |
| Cumberland County | 217-849-3931 |
| DeKalb County | 815-758-8194 |
| DeWitt County | 217-935-5764 |
| Douglas County | 217-253-2713 |
| DuPage County | 312-682-7485 |
| Edgar County | 217-465-8585 |
| Edwards County | 618-445-2934 |
| Effingham County | 217-347-7773 |
| Fayette County | 618-283-2753 |

| | |
|---|---|
| Ford County | 217-388-7791 |
| Franklin County | 618-439-3178 |
| Fulton County | 309-547-3711 |
| Gallatin County | 618-272-4561 |
| Greene County | 217-942-6996 |
| Grundy County | 815-942-2725 |
| Hamilton County | 618-643-3416 |
| Hancock County | 217-357-2150 |
| Henderson County | 309-924-1471 |
| Henry County | 309-937-2424 |
| Iroquois County | 815-432-5416 |
| Jackson County | 618-687-1727 |
| Jasper County | 618-783-2521 |
| Jefferson County | 618-242-0780 |
| Jersey County | 618-498-4821 |
| Jo Daviess County | 815-858-2273 |
| Johnson County | 618-658-5322 |
| Kane County | 312-584-6166 |
| Kankakee County | 815-939-3626 |
| Kendall County | 312-553-5824 |
| Knox County | 309-342-5108 |
| Lake County | 312-223-8627 |
| LaSalle County | 815-433-0707 |
| Lawrence County | 618-943-5018 |
| Lee County | 815-857-3525 |
| Livingston County | 815-844-3622 |
| Logan County | 217-732-8289 |
| McDonough County | 309-837-3939 |
| McHenry County | 815-338-3737 |
| McLean County | 309-828-6494 |
| Macon County | 217-877-6042 |
| Macoupin County | 217-854-9604 |
| Madison County | 618-656-7200 |
| Marion County | 618-548-1446 |
| Marshall-Putnam Counties | 309-364-2356 |
| Mason County | 309-543-3308 |
| Massac County | 618-524-2270 |
| Menard County | 217-632-7491 |
| Mercer County | 309-582-5106 |
| Monroe County | 618-939-6617 |
| Montgomery County | 217-532-5763 |
| Morgan County | 217-243-2712 |
| Moultrie County | 217-728-4318 |
| Ogle County | 815-732-2191 |
| Peoria County | 309-686-6033 |
| Perry County | 618-357-2126 |
| Piatt County | 217-762-2655 |
| Pike County | 217-285-2281 |
| Pope-Hardin Counties | 618-695-2441 |
| Pulaski-Alexander Counties | 618-745-6310 |
| Randolph County | 618-443-4364 |
| Richland County | 618-395-2191 |
| Rock Island County | 309-796-1233 |
| St. Clair County | 618-233-1047 |
| Saline County | 618-253-7711 |
| Sangamon County | 217-782-4617 |
| Schuyler County | 217-322-6033 |
| Scott County | 217-742-3172 |
| Shelby County | 217-774-4321 |
| Stark County | 309-286-5421 |
| Stephenson County | 815-233-4125 |
| Tazewell County | 309-347-6614 |
| Union County | 618-833-5341 |
| Vermilion County | 217-442-8615 |
| Wabash County | 618-262-5725 |
| Warren County | 309-734-5161 |
| Washington County | 618-327-8881 |
| Wayne County | 618-842-3702 |
| White County | 618-382-9276 |
| Whiteside County | 815-772-4075 |
| Will County | 815-727-9296 |
| Williamson County | 618-993-3304 |
| Winnebago County | 815-987-7379 |
| Woodford County | 309-467-3413 |

## CONVERSIONS

**Fluid**

1/6 fluid ounce (oz) = 1 teaspoon (tsp)
1/2 fluid ounce = 1 tablespoon (tbs) = 3 teaspoons
1 fluid ounce = 2 tablespoons = 1/8 cup
8 fluid ounces = 1 cup = 1/2 pint (pt)
16 fluid ounces = 2 cups = 1 pint
32 fluid ounces = 4 cups = 1 quart (qt)
128 fluid ounces = 16 cups = 1 gallon (gal)

**Linear**

1 inch = 2 1/2 centimeters (cm) = 25 1/2 millimeters (mm)
1 foot (ft) = 12 inches (in)
1 yard (yd) = 3 feet
1 rod = 5 1/2 yards = 16 1/2 feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

**Area**

144 square inches = 1 square foot
9 square feet = 1 square yard
30 1/4 square yards = 1 square rod
= 272 1/4 square feet
43,560 square feet = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

**Weight**

1 ounce = 28 1/3 grams (g)
1 pound (lb) = 16 ounces = 453 1/2 grams
2 1/5 pounds = 1 kilogram (kg) = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms

## DILUTION TABLES

**Amount of Liquid Pesticide Product Required to Obtain Recommended Rate**

| Concentration of liquid formulation | Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water | | | | |
|---|---|---|---|---|---|
| | ¼ lb | ½ lb | 1 lb | 2 lb | 3 lb |
| | *Amount of pesticide product required* | | | | |
| 1 lb/gal | 1 qt | 2 qt | 1 gal | 2 gal | 3 gal |
| 1½ lb/gal | 1⅓ pt | 1⅓ qt or 2⅔ pt | 5⅓ pt | 5⅓ qt | 2 gal |
| 2 lb/gal | 1 pt | 1 qt | 2 qt | 1 gal | 6 qt |
| 4 lb/gal | 8 oz | 1 pt | 1 qt | 2 qt | 3 qt |
| 6 lb/gal | 6 oz | 10 oz | 1⅓ pt | 1⅓ qt | 2 qt |
| 8 lb/gal | 4 oz | 8 oz | 1 pt | 1 qt | 3 pt |

**Amount of Dry Pesticide Product Required to Obtain Recommended Rate**

| Concentration of dry formulation | Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water | | | | |
|---|---|---|---|---|---|
| | ¼ lb | ½ lb | 1 lb | 2 lb | 3 lb |
| | *Amount of pesticide product required* | | | | |
| 15% | 1⅔ lb | 3⅓ lb | 6⅔ lb | 13 lb | 20 lb |
| 25% | 1 lb | 2 lb | 4 lb | 8 lb | 12 lb |
| 40% | 10 oz | 1¼ lb | 2½ lb | 5 lb | 7½ lb |
| 50% | 8 oz | 1 lb | 2 lb | 4 lb | 6 lb |
| 65% | 6 oz | 12 oz | 1½ lb | 3 lb | 4½ lb |
| 75% | 5⅓ oz | 11 oz | 1½ lb | 2⅔ lb | 4 lb |
| 80% | 5 oz | 10 oz | 1¼ lb | 2½ lb | 3¾ lb |